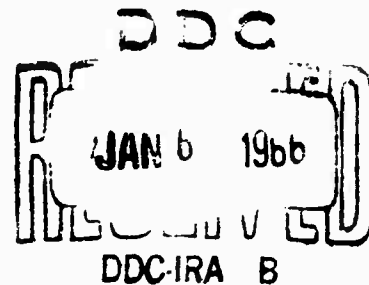GD/C-DBE-65-028
Space Science Laboratory

EMPIRICAL INFRARED ABSORPTION COEFFICIENTS

OF H_2O FROM 300°K TO 3000°K

C. C. Ferriso
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Technical Report

Research and Advanced Technology Department

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GENERAL DYNAMICS CONVAIR

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i

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (CON'T)

ABSTRACT

A set of absorption coefficients for water vapor as functions of temperature has been empirically dedecued from existing quantitative absorption and emission spectra between 1 and 22 μ. The basic assumption was made that, for optically thick gases, the curve of growth is given by a statistical model. The absorption coefficients were obtained for each vibration-rotation band by adjusting the band averaged line half widths and line spacings such that the integral of the absorption coefficients was equal to the known integrated intensity of the particular band at a given temperature. The effect of foreign gas broadening and non-resonant water molecule broadening was included. The present results are compared with independent theoretical and experimental results and the agreement is satisfactory.

INTRODUCTION

For the purpose of analyzing and predicting rocket plume radiation, it is necessary to have available a representation of the spectral properties of all the major radiating species as functions of the relevant parameters. This representation should be as simple as possible yet detailed enough to allow for determining the essential features of the spectrum.

The major infrared molecular radiators in present rocket exhausts are carbon dioxide, water vapor, and several diatomic molecules. The spectral properties of carbon dioxide and many of the diatomic molecules have been reported in the literature. However, there are at present no theoretical predictions of the complete water vapor spectra in the infrared region at high temperatures. It is the purpose of this paper to derive a set of absorption coefficients for water vapor between 50 and 7500 cm^{-1} in the temperature range from 300° to 3000°K from available experimental data.

During the last few years, a large number of spectra of high temperature water vapor between 1 and 22 microns have been published.[1-12] These spectra have been measured by different techniques and cover the temperature range from 300° to 2700°K. The optical depths range between about 0.2 to 100 cm·atm, total pressures range between 50 mmHg and 10 atm, but the range of parameters covered at any one temperature is rather limited, especially at higher temperatures. These measurements show that the spectral emissivity depends on the following independent parameters: absorption coefficient, wavelength, temperature, partial pressure, total pressure, line broadening ability of foreign gases, and pathlength. The

1

most important parameter is the absorption coefficient as a function of wavelength and temperature. If sufficient thin-gas spectra at all temperatures were available, a set of absorption coefficients could be derived directly. However, this is not the case. In order to obtain absorption coefficients from measured spectra in which the gas was not thin, the functional relationship between emissivity or absorptivity and optical depth (curve of growth) must be known. A number of theoretical models for the curves of growth have been developed.[13,14] Goody[14] has treated the absorptivity of a gas whose spectral lines are distributed statistically both in position and intensity. In the same paper the applicability of the statistical model to water vapor was established. Also, Howard, Burch, and Williams[15,16] have applied this model to water at room temperature and 1 atm pressure and found good agreement over a wide range of optical depths.

The expression for the spectral curve of growth contains the mean spectral absorption coefficient, the optical depth, and a rotational fine structure term which is dependent on a collision parameter and the mean line spacing.

We propose to use these curves of growth to determine the mean spectral absorption coefficients from non-thin water spectra by adjusting the fine structure term in such a way that the integral of the absorption coefficients over a given vibration-rotation band results in the known value of the band intensity.

DETERMINATION OF ABSORPTION COEFFICIENTS FROM NON-THIN GAS SPECTRA

In the statistical model the spectral emissivity is given by

$$\epsilon(\omega) = 1-\exp\left[-\frac{W(\omega)}{d(\omega)}\right] \tag{1}$$

2

where $W(\omega)$ is the average equivalent width and $d(\omega)$ is the average line spacing. Goody[14] has shown that the curves of growth are quite insensitive to the choice of the line intensity distribution functions. When the smoothed absorption coefficient and mean line width to line spacing ratio are chosen so that the curves of growth agree in the optically thin and in the square root limits, the values of $\frac{W}{d}$ corresponding to a delta function, an exponential or a 1/S distribution differ by at most 25%.

In the present reduction of the experimental data, we have used the intermediate form corresponding to an exponential distribution of line intensities:

$$\frac{W(\omega)}{d(\omega)} = \frac{k(\omega)u}{\sqrt{1+ \frac{k(\omega)u}{4a(\omega)}}} \tag{2}$$

where $k(\omega)$ is the mean absorption coefficient, u the optical depth (at STP), and $a(\omega)$ the fine structure parameter. The fine structure term $a(\omega)$ is proportional to the local mean value of the ratio of the collision half-width to the line spacing, γ/d. It is to be noted that the value of d, deduced from experimental curves of growth, is only meaningful when interpreted in terms of a particular intensity distribution function. In the present analysis, we have chosen to normalize the value of d so that it is appropriate for a delta function distribution (i.e., a = γ/d).

The line width is expected to be proportional to the number of collisions experienced by the water molecule per unit time. Since

3

collisions with other molecules of water vapor are more effective than those with molecules of a different species, it has been found[17] that good agreement with the experimental data at room temperature has been obtained by assuming that the line width is proportional to $(\gamma_{H_2O}p_{H_2O} + \gamma_x p_x)$, where γ = line width and the subscript x designates the foreign gas. Since we want to extend this treatment to higher temperatures, the effect of interactions between resonating and non-resonating water molecules and their temperature dependency[18,19] should be taken into account. Thus, we obtain a three term expression,

$$a(\omega)\ d(\omega) = p_{H_2O}\left(\gamma^o_{H_2O}(\omega)\ \frac{T_o}{T} + \gamma'^o_{H_2O}(\omega)\ \sqrt{\frac{T_o}{T}}\right) + p_x \gamma^o_x(\omega)\ \sqrt{\frac{T_o}{T}}\ , \quad (3)$$

where γ'_{H_2O} is the line width due to non-resonating dipole interactions of H_2O at T_o. The following assumptions are now made: The line widths $\gamma^o(\omega)$ due to interactions with resonating and non-resonating water molecules and with foreign gas species, which are functions of frequency, can be approximated by a band averaged value, so that the frequency dependence of the broadening term $a(\omega)$ appears only through the mean line spacing $d(\omega)$. Thus, Eq. (3) becomes

$$a(\omega) = \frac{\overline{\gamma^o_{H_2O}}}{d(\omega)}\ p_T\ \sqrt{\frac{T_o}{T}}\left[c\left(\sqrt{\frac{T_o}{T}} + \overline{\sigma}'\right) + (1-c)\overline{\sigma}_x\right] \quad (4)$$

where $\overline{\sigma}' = \overline{\gamma'^o_{H_2O}}/\overline{\gamma^o_{H_2O}}$ and $\overline{\sigma}_x = \overline{\gamma^o_x}/\overline{\gamma^o_{H_2O}}$ and c is the mole fraction of water. Values of $\overline{\gamma^o_{H_2O}}$ and $\overline{\sigma}_x$ are given in the literature[17-20] and the following values will be used in the present study: $\overline{\gamma^o_{H_2O}} = 0.5\ cm^{-1}atm^{-1}$; $\overline{\sigma}_{N_2} = 0.18$;

$\bar{\sigma}_{0_2}$ = 0.09. Since no value for $\bar{\sigma}'$ is given, we will assume initially that
$\bar{\sigma}'$ is approximately 0.1. As a next step we assume that a band averaged
mean line spacing d can be used so that $a(\omega)$ becomes independent of the
frequency and we can write Eq. (2) as

$$\frac{W}{d}(\omega) = \frac{k(\omega)u}{\sqrt{1+ \dfrac{k(\omega)u}{4\bar{a}}}} \tag{5}$$

The frequency-independent broadening term $\bar{a}$ can then be evaluated from
existing spectra, where $\frac{W}{d}(\omega) = - \ell n \; (1-\epsilon[\omega])$, by using as the second of
the two equations required to define $k(\omega)$ and $\bar{a}$

$$\int_{band} k(\omega)d\omega = \alpha^{o}\phi(T), \tag{6}$$

where α^{o} is the known integrated intensity at STP of the band in question
and $\phi(T)$ is a known function of the temperature.[21] It can be shown that,
in the temperature range of interest here (up to $\sim$ 3000°K), the function
$\phi(T) \equiv 1$ for fundamental bands in general. However, as pointed out recently
by W. S. Benedict,[22] the 6.3-μ fundamental band of H_2O may not obey this rule
because of strong rotation-vibration interaction. Room temperature measure-
ments of the 6.3-μ band indicate a value of 250 (cm^{-1} per cm at STP), while
measurements at temperatures of 2700°K indicate a value of 380 (cm^{-1} per cm
at STP). Therefore, an empirical function $\phi(T) = 250 + 0.05T$ has been used
to describe the temperature dependence of the 6.3-μ band between 300°K and
3000°K. For combination and overtone bands, $\phi(T)$ was given in Ref. 21 for
the 1.87- and 1.38-μ bands. The values of α^{o} in (cm^{-1} per cm at STP) for
the four major vibration-rotation bands used in the present analysis are
shown in Table I.

5

Table I: Integrated intensities used in present analyses.

Bands	6.3 μ	2.7 μ	1.87 μ	1.38 μ
α_i^o	250 ± 20%	230 ± 15%	26 ± 15%	21 ± 15%

The pure rotational band could not be evaluated in this fashion since
no measurements for the total band exist. However, mean absorption coef-
ficients were calculated in Ref. 11; these have been included in the
present tabulation.

Approximately 80 published emission and absorption spectra were
used in the present analysis. The spectral emissivity at intervals of
25 cm^{-1}, together with the optical depth, temperature and total pressure
served as inputs in a computer program. When the experimentally determined
spectra were given with a higher resolution than 25 cm^{-1}, the curves were
smoothed by hand. The absorption coefficient was calculated from

$$k(\omega) = \frac{1}{8\bar{a}u}\left[\frac{W}{d}(\omega)\right]^2 + \left\{\left(\frac{1}{8\bar{a}u}\left[\frac{W}{d}(\omega)\right]^2\right)^2 + \left[\frac{1}{u}\frac{W}{d}(\omega)\right]^2\right\}^{\frac{1}{2}} \qquad (7)$$

by choosing $\bar{a}$ such that Eq. (6) was satisfied (see Fig. 1). If

$$\frac{1}{u}\int \ell n \frac{1}{1-\epsilon(\omega)} \, d\omega \approx \alpha \quad , \qquad (8)$$

the spectrum was from a thin gas sample and the absorption coefficients
could be determined directly.

Two sources of error in the determination of $\bar{a}(T)$ and $k(\omega,T)$ are
recognized:

1) Error in the measurements of the state parameters of the gas

6

or of the spectral emissivity or absorptivity, and

2) Uncertainty in the integrated intensities of the vibration-
    rotation bands.

An analysis was performed in which reasonable error limits for the state
parameters and the integrated intensities were selected. The state param-
eters T, u, c, p_T, and the emissivity were varied by $\pm$ 5%, while α was
varied by $\pm$ 20%. It is believed that these variations constitute upper
limits, since many experimenters quote smaller error limits. It is
found that the uncertainty of $\pm$ 5% in the measured emissivity has the
greatest influence on $\bar{a}(T)$ and $k(\omega,T)$ ($\Delta\bar{a} \approx \pm$ 100%, $\Delta k \approx \pm$ 20%). An
uncertainty of $\pm$ 20% in α gives $\Delta\bar{a} \approx \pm$ 20% and $\Delta k \approx \pm$ 15%. All other
parameters influence $\bar{a}$ and k by $\pm$ 5% or less.

RESULTS

The average absorption coefficients obtained by the method described
in the previous section are tabulated in Table II, and are plotted in Fig. 2
for the two extreme temperatures, 300°K and 3000°K. In general, the mean
deviation of the absorption coefficients taken from the individual spectra
is within $\pm$ 20%. As an example, in Fig. 3 k at 1250 cm^{-1} is plotted versus
temperature. The solid line represents the mean of the individual points.
From this curve, the absorption coefficients at 300°, 600°, 1000°, 1500°,
2000°, 2500°, and 3000°K are selected and entered in Table II. In some
portions of the spectra, where the absorption coefficient changes rapidly,
a much greater spread in the individual absorption coefficients is
observed. In Fig. 4 k at 3750 cm^{-1}, the Q-branch region of the 2.7-μ
band, is plotted versus temperature. The large spread here is probably
introduced by small errors in the wavenumber calibration. Also, the
absorption coefficients in the spectral regions between the individual
bands ("troughs") and in the region $\omega >$ 7500 cm^{-1} are not very certain

7

because of lack of sufficient data. Since, at the present time, there are no data for temperatures below 2000°K in this region, no absorption coefficients are listed in Table II.

The average line spacings $\bar{d}(T)$ obtained from the values of $\bar{a}(T)$, using Eq. (4), are plotted in Fig. 5. Data from approximately 80 spectra of the 2.7- and 6.3-μ band are represented. Each point has about a factor of 2 uncertainty. The overall spread of points is mostly within a factor of 2 to 3, but can be as large as a factor of 10 (at 1200°K for instance). The straight line is a least square fit to the points and is given by

$$\bar{d}(T) = \exp[- .00106T + 1.21] \tag{9}$$

One point at 2200°K is obtained from the rotational band. The point from Oppenheim[23] at 1200°K is a simple average taken from his measured $(2\pi\gamma^o/d)$ values (see Fig. 6). The majority of points in Fig. 5 are restricted to temperatures < 1800°K because the high-temperature measurements made with the rocket motor in this laboratory were in the thin gas region where Eq. (8) applies.

The two combination bands at 1.87 μ and 1.38 μ are much weaker than the fundamental bands. Room temperature absorption spectra[8] of the 1.87-μ band indicate that the value of $\bar{d}$ is practically the same as that obtained from the two fundamental bands. Values of $\bar{d}$ derived from the data presented by Nelson[3] are generally higher than values of $\bar{d}$ obtained from his data for the two fundamental bands, but the experimental uncertainty in his measurements does not permit any definite conclusions. Our own data were always obtained at low optical depths, so that no $\bar{d}$ could be obtained. In the absence of further information, it is assumed that the $\bar{d}(T)$ for the two combination bands is the same as that deduced for the fundamental bands.

8

The rotational band is very strong and fine structure affects the measurements even at the highest temperatures measured (~ 2700°K).[11] However, since the measurements were carried out only up to 22 μ, no total band strength could be obtained. Thus, the procedure used before for the vibration-rotation bands could not be employed. Additional knowledge about the integrated intensity of this band up to 22 μ was needed which presupposed the knowledge of the spectral absorption coefficient. The theoretical relationships of Ref. 11 were used here in a semi-empirical fashion by adjusting the effective mean rotational constant slightly to fit the observed spectra in the far wing of the rotational band. The values of k thus determined were used to calculate

$$\int_{450 \text{ cm}^{-1}}^{1000 \text{ cm}^{-1}} k(\omega,T) \, d\omega = \alpha'(T) \tag{10}$$

which then replaced Eq. (7).

COMPARISON WITH OTHER THEORETICAL AND EXPERIMENTAL RESULTS

A check of the absorption coefficients derived here against independent work is possible for some selected temperatures. Benedict[24,25] has obtained absorption coefficients for individual lines in the 6.3-μ band at ≈ 300°K and ≈ 600°K and in the 2.7-μ band for ≈ 300°K. We have averaged Benedict's values and compared them with the absorption coefficients taken from this work (see Figs. 7, 8, and 9). Oppenheim's[23] detailed measurement of the absorption coefficients in the 2.7-μ band at 1200°K is compared in Fig. 10. Goldstein's[7] determination of the absorption coefficients of the 1.38-, 1.87-, 2.7-, and 6.3-μ bands at ≈ 500°K and 1200°K are compared with the present values in Figs. 11 through 16. One set of experimental data has recently become available. Simmons, Arnold, and

9

Smith[26] have measured the 2.7-μ bands between 700° and 1200°K at various optical paths. Since their data were not included in our derivation of the absorption coefficients and band averaged line spacing, they provide us with an independent check for calculating thick gas spectra of the 2.7-μ bands at around 1000°K. The result of this comparison for some of the spectra is given in Figs. 17-22. Similar agreement is found with the other spectra from Ref. 26.

In a consistency check, some of the measured spectra, which were used to obtain a band-averaged line spacing and average absorption coefficients, are recalculated using the d from Fig. 5 (dashed line) and the k's from Table II. In Fig. 23 we compare Nelson's[3] measurements of the 6.3-μ band at 1111°K with the present representation of $k(\omega)$ and T. In Figs. 24, 25, and 26, the spectra obtained in this laboratory are compared at 2200°K. In Fig. 27, one spectrum obtained by Burch and Gryvnak[2] of the 2.7-μ band at 1200°K is compared with the present results. In general the agreement is adequate for the present representation of H_2O at high temperatures.

CONCLUDING REMARKS

The absorption coefficients averaged over 25 cm^{-1} intervals given in this study for temperatures greater than 300°K represent the "best" values available at the present time. (The values at 300°K were included here only for completeness. More detailed tabulations are available in the literature, for example, References 24 and 27). The absorption coefficients derived here have been based on nearly all the available published spectra, using a statistical model for the curve of growth and a frequency-independent fine structure term to extrapolate to zero pathlength. In the slowly varying portions of the spectra, the uncer-

tainties are believed to be within ± 20%, while in portions of the spectra where steep changes occur, the uncertainties may be higher. Also the values in the troughs between the vibration-rotation bands are not very certain because of the lack of sufficient data.

The different frequency-independent fine structure terms obtained from the analysis of the optically thick spectra were used to calculate band-averaged line spacings as functions of temperature. These individual points are uncertain by a factor of 2 and although the spread can be as high as a factor of 10 (at 1200°K for instance), the mean values (dashed curve in Fig. 5) are believed to be uncertain by a factor of 2 only. That these mean values may be used for first approximations in the calculation of moderately thick gases was shown in the comparison with some of the spectra by Simmons, et.al.,[26] in Figs. 17-22. More accurate calculations for very thick gases will require a detailed evaluation of the dependence of the fine structure parameters on both temperature and wavelength.

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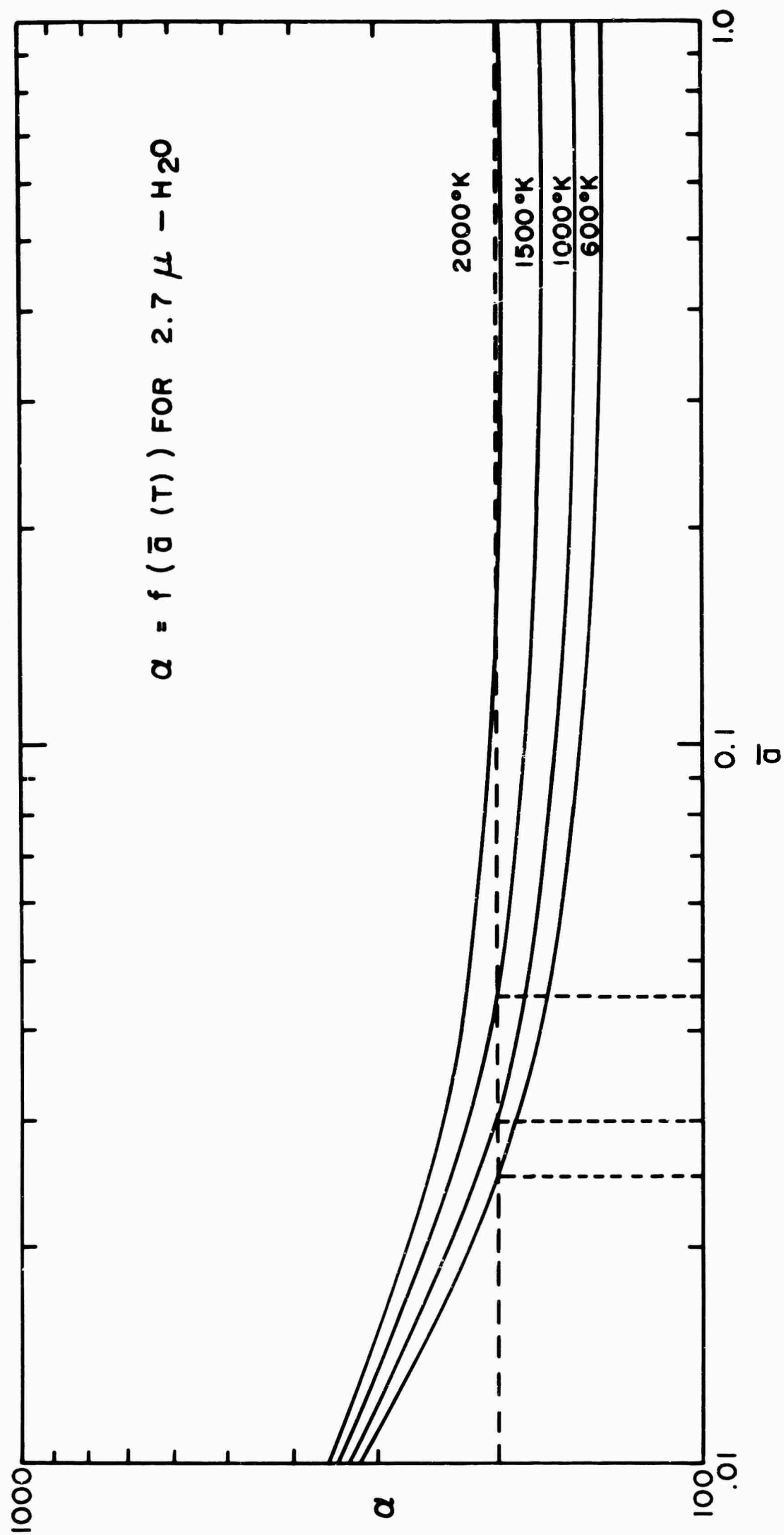
Figure 1. The integrated intensity α of the 2.7-μ band as function of $\bar{a}$ for various temperatures.

14
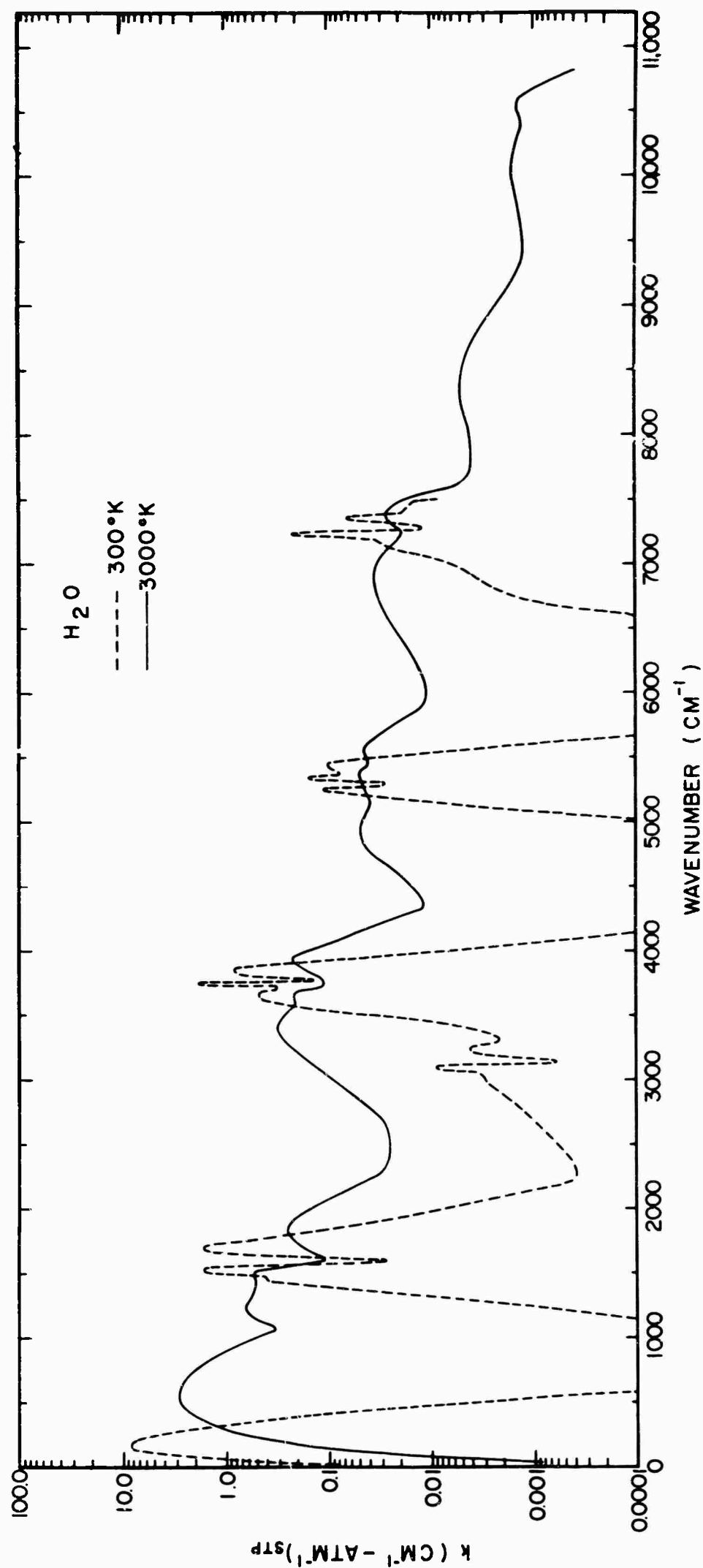
Figure 2. Plot of absorption coefficients at 300°K and 3000°K.

15
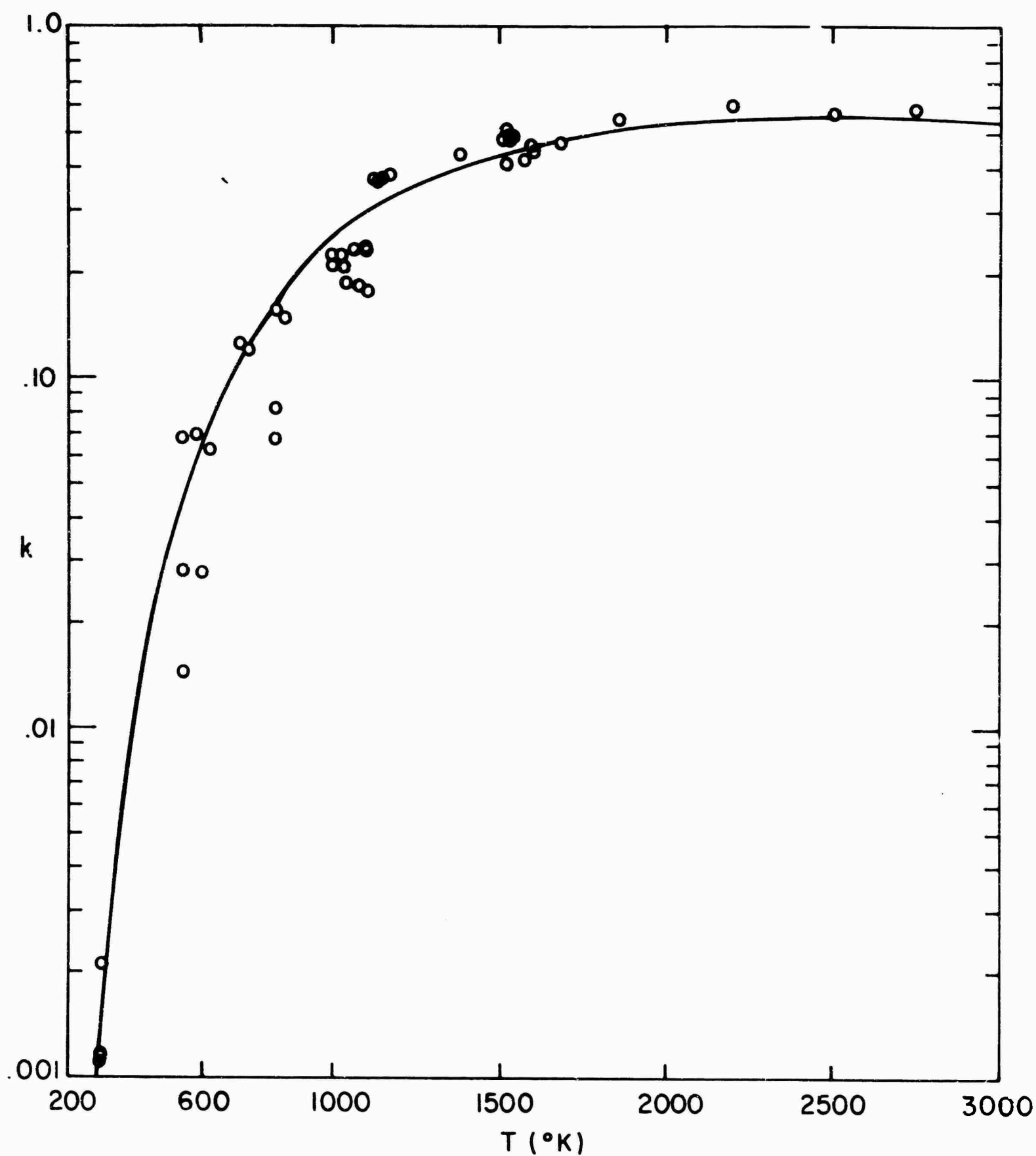
Figure 3. Compilation of average absorption coefficients versus temper-
ature at 1250 cm^{-1} as obtained from spectra taken by several
investigators. Solid line is the average value

16
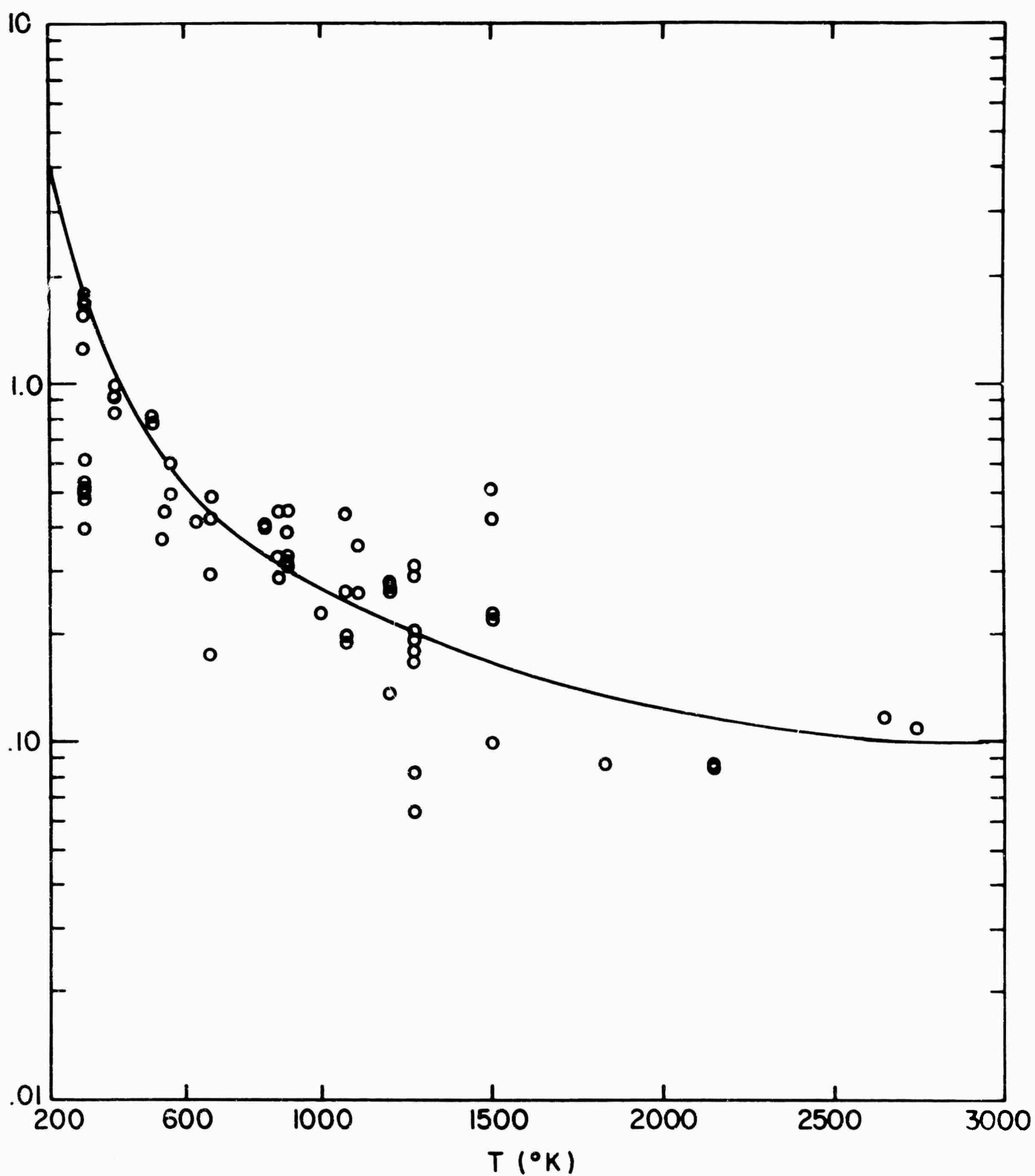
Figure 4. Compilation of average absorption coefficients versus temperature at 3750 cm^{-1} as obtained from spectra taken by several investigators. Solid line is the average value.

17
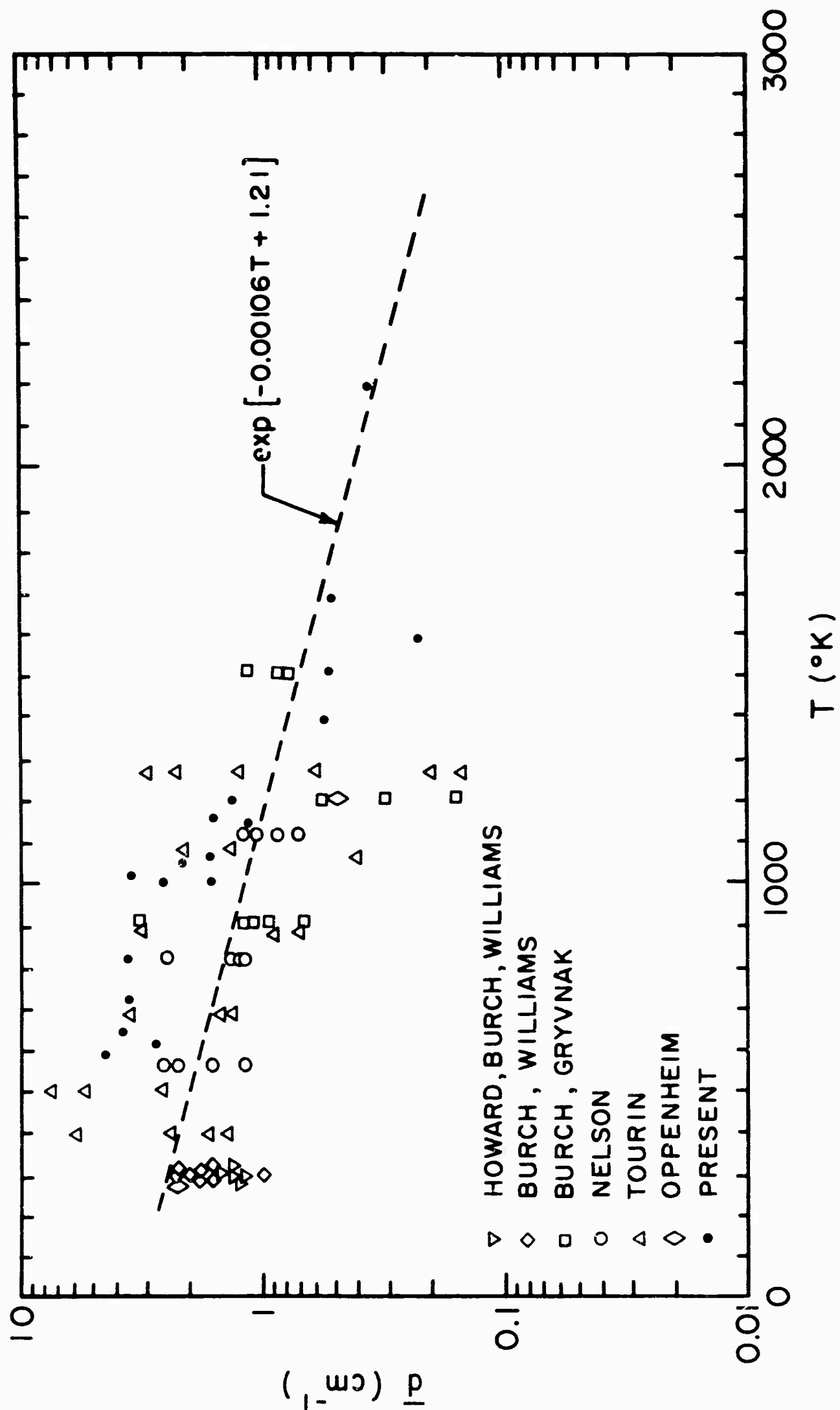
Figure 5. Compilation of band averaged line spacings d versus temperature as obtained from spectra taken by several investigators.
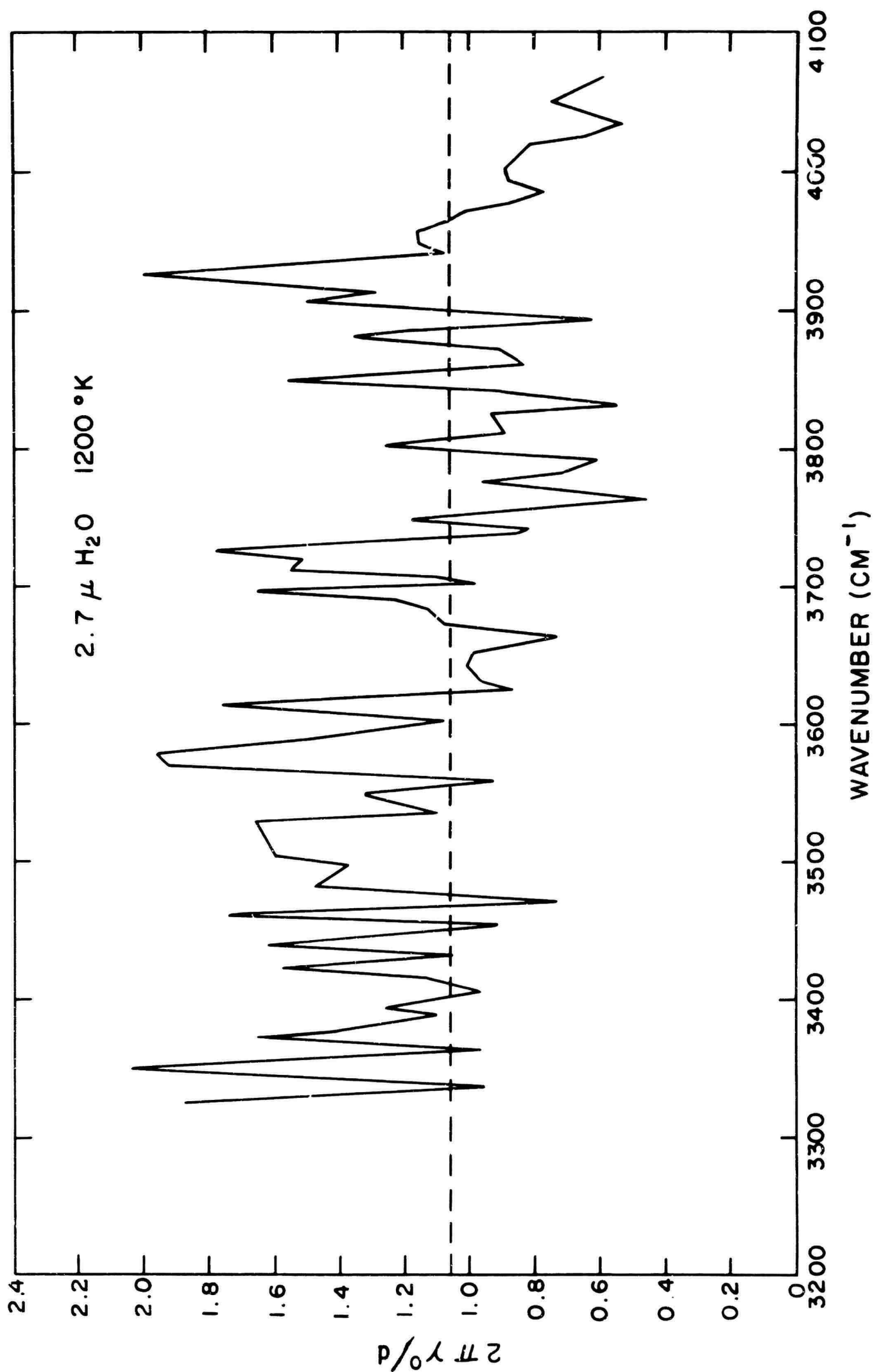
Figure 6. The ratio of line width to line spacing ($2\pi\gamma^{\circ}/d$) as function of wavenumber, obtained by Oppenheim of the 2.7-μ band at 1200°K.
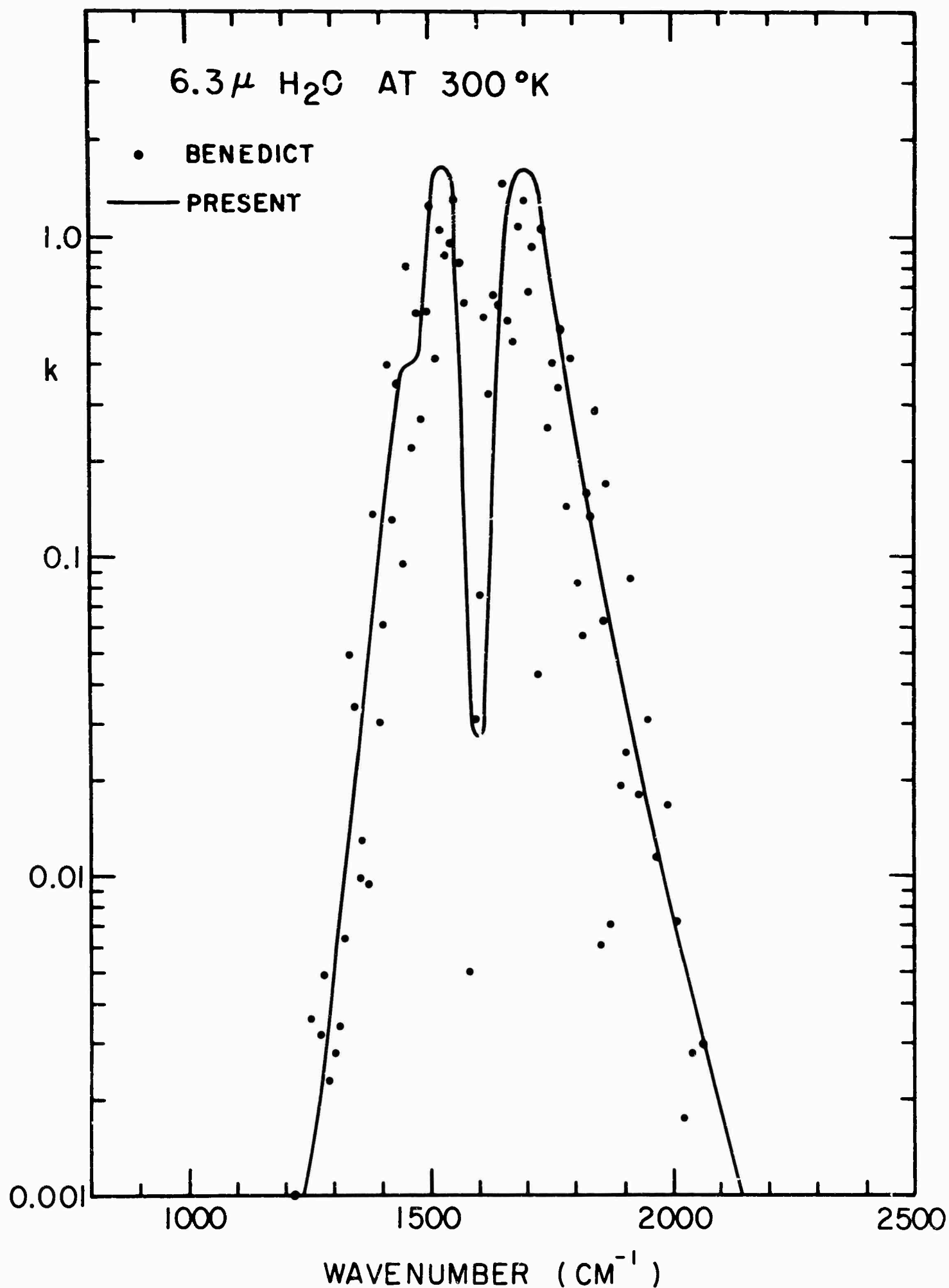
Figure 7. Comparison of absorption coefficients, obtained by Benedict at 300°K, averaged over 25 cm^{-1}.

20
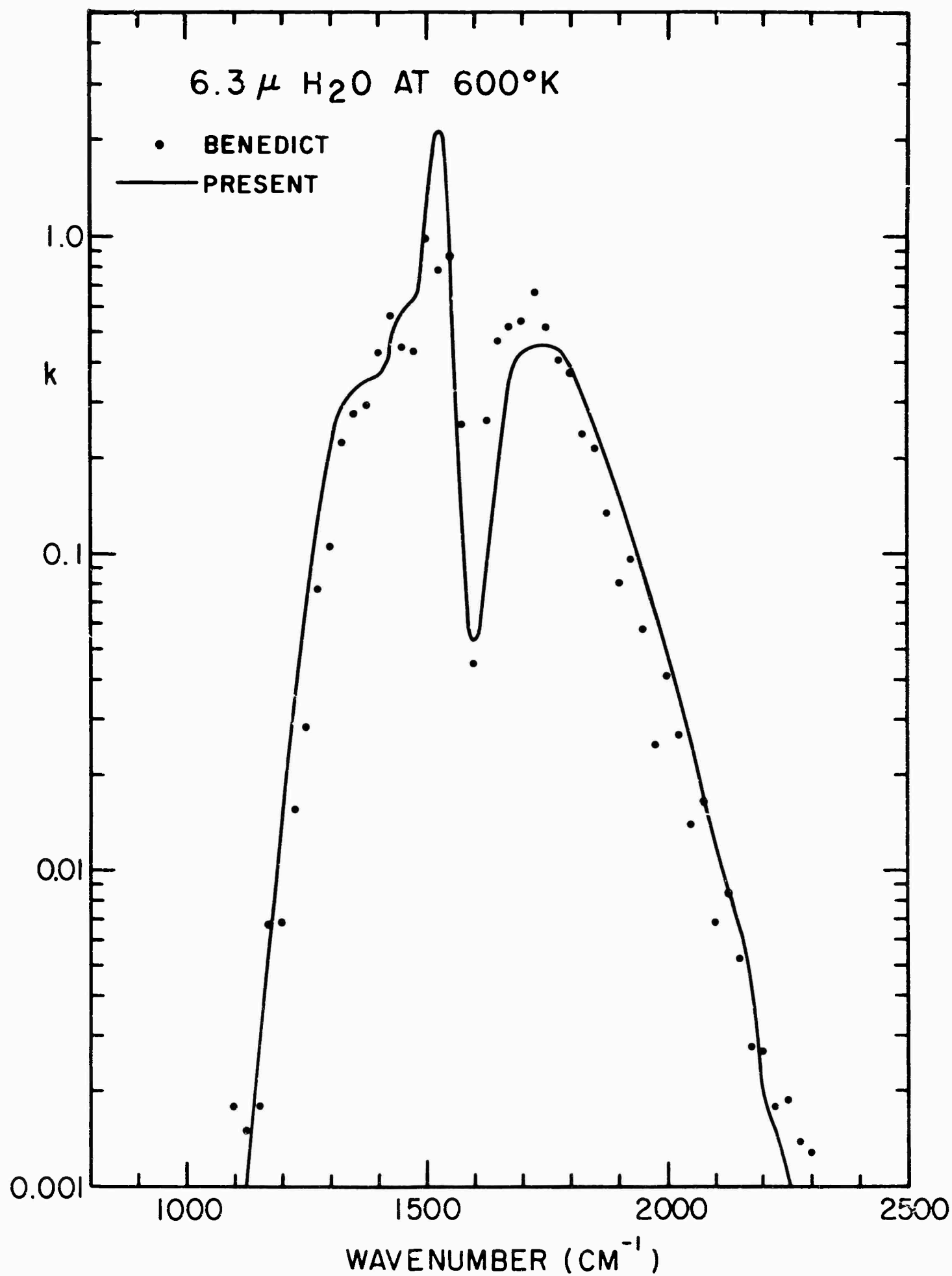
Figure 8. Comparison of absorption coefficients, obtained by Benedict at 600°K, averaged over 25 cm⁻¹.
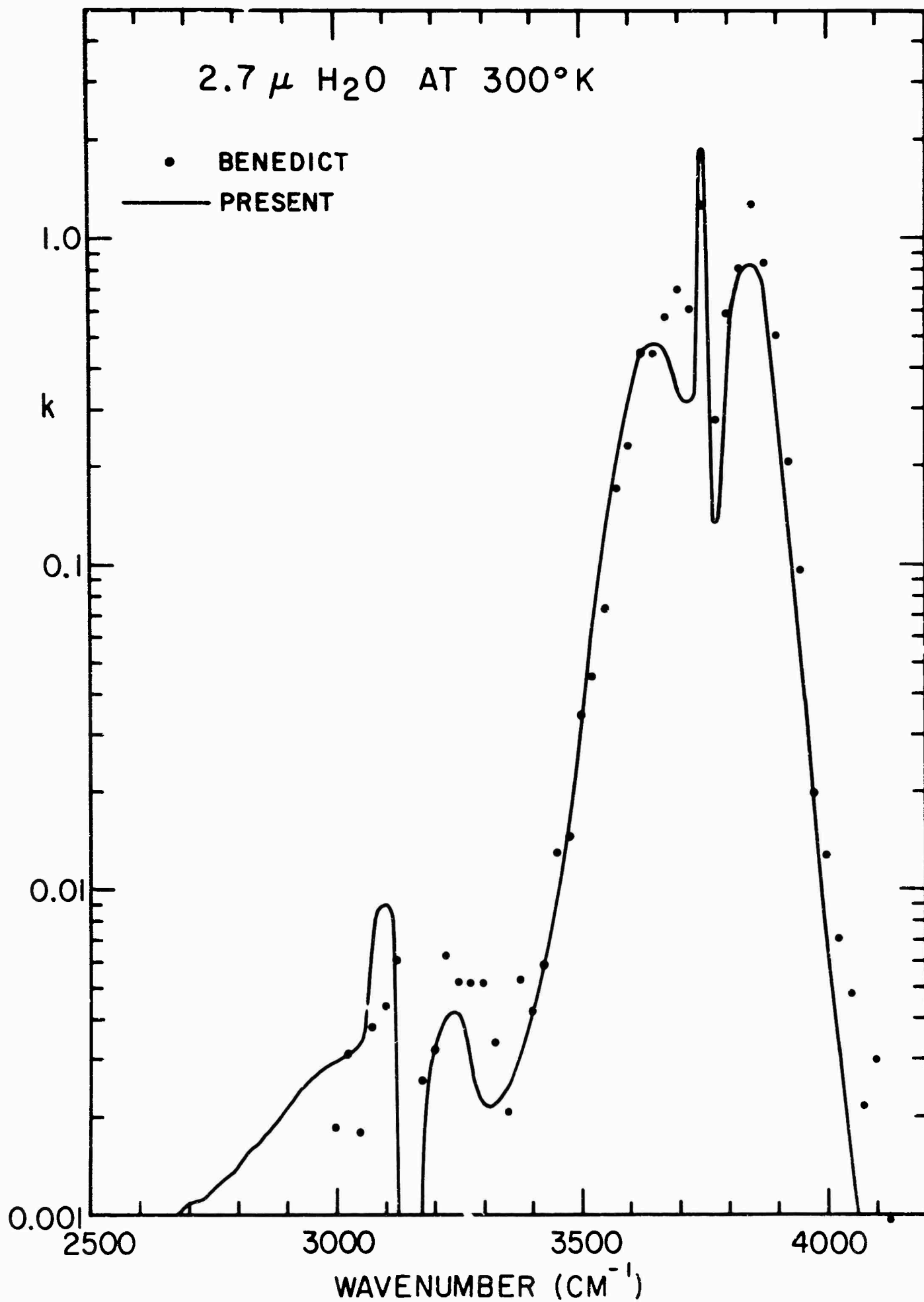
Figure 9. Comparison of absorption coefficients, obtained by Benedict at 300°K, averaged over 25 cm⁻¹.
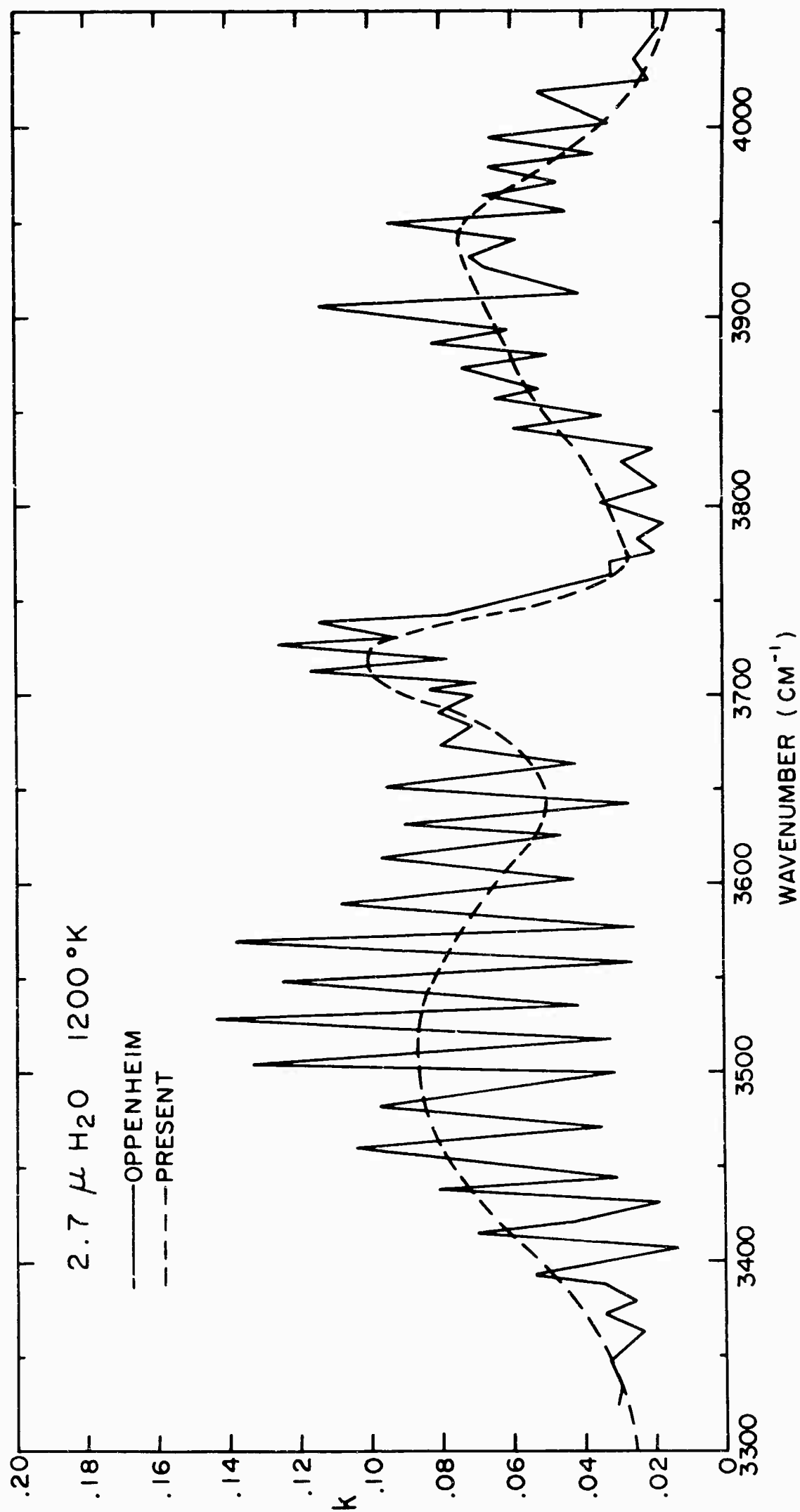
Figure 10. Comparison of absorption coefficients, obtained by Oppenheim.

23
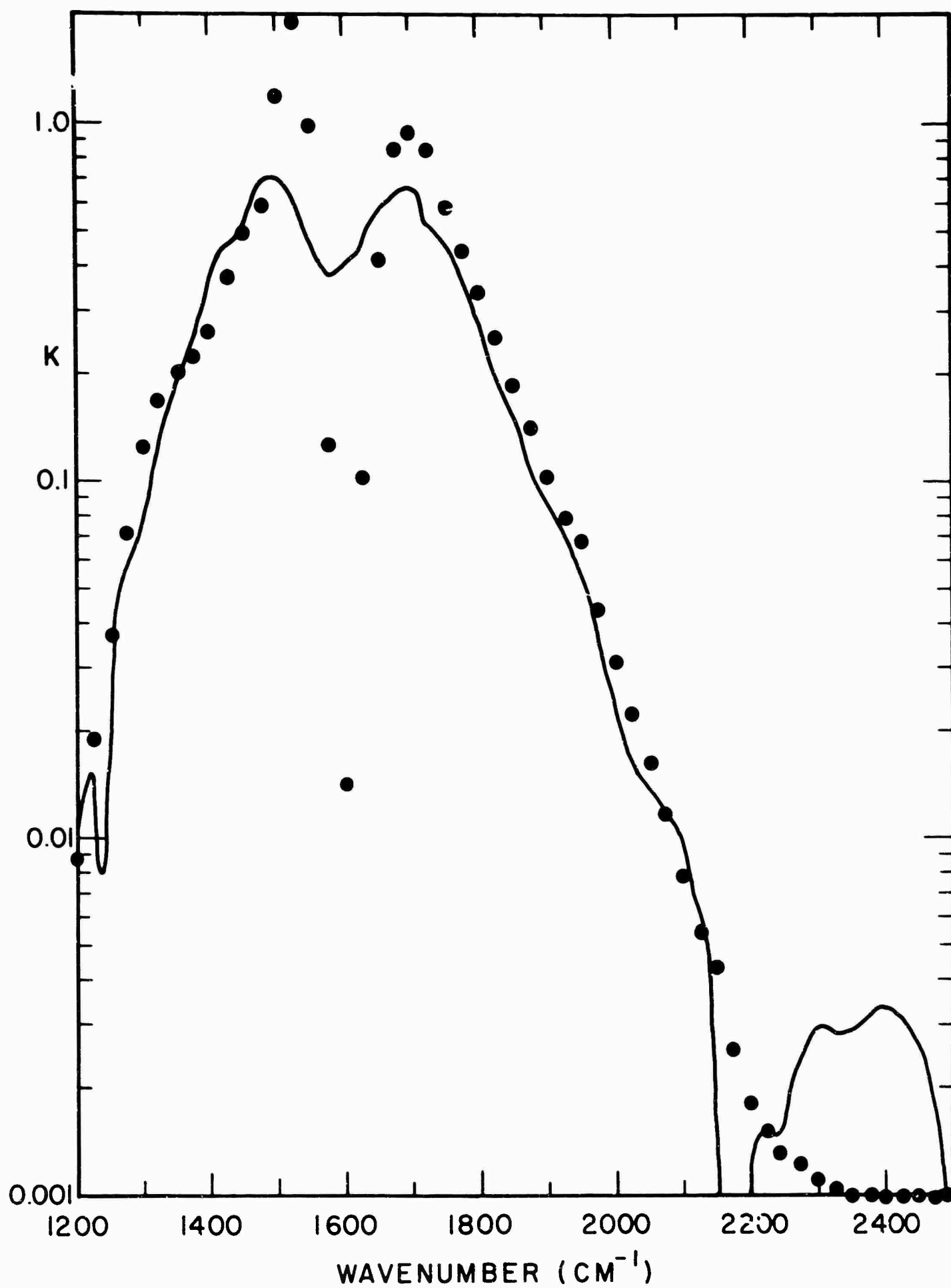
Figure 11. Comparison of absorption coefficients, obtained by Goldstein
of the 6.3-μ band at 473°K (solid line). Present values are
given as points.
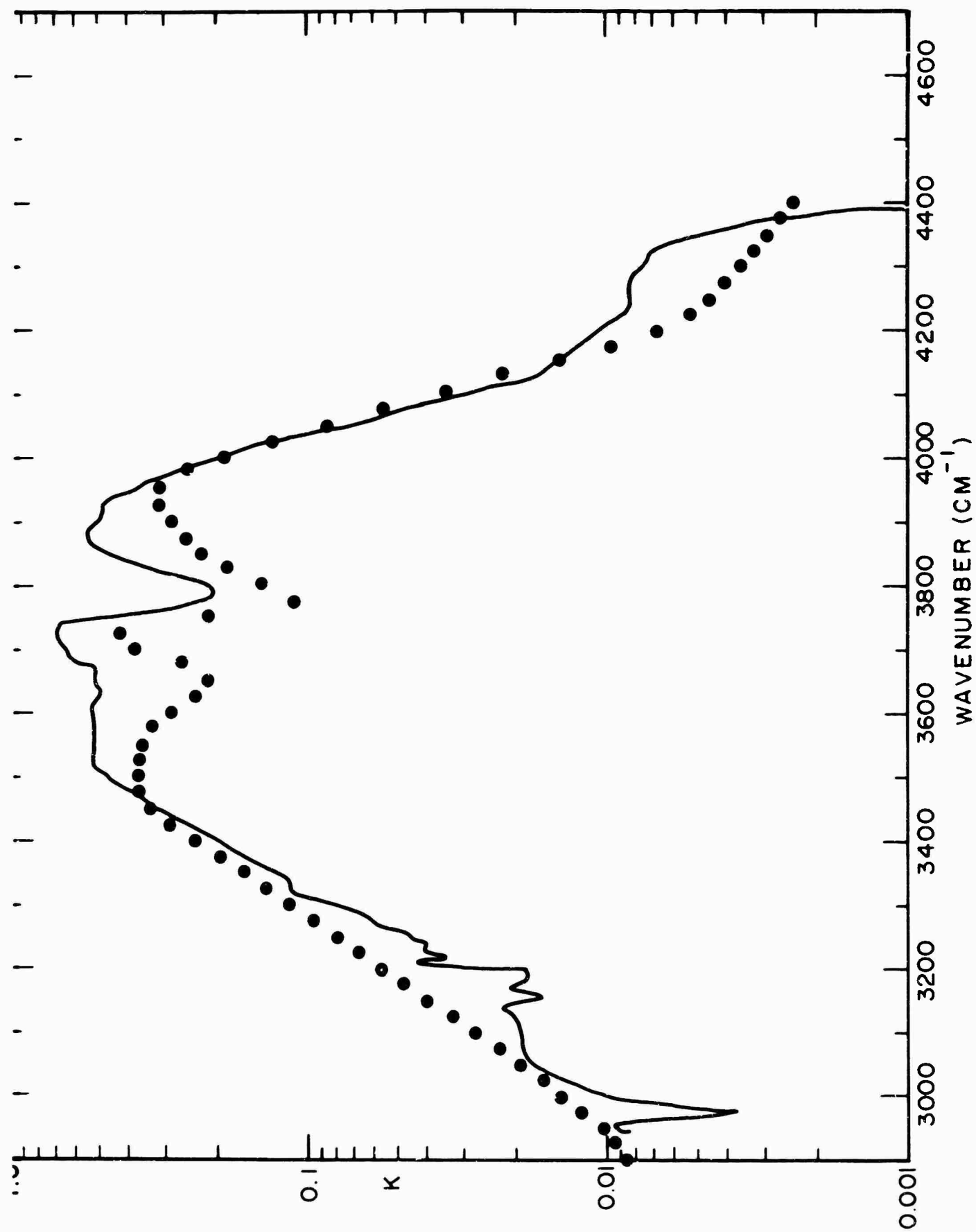
Figure 12. Comparison of absorption coefficients, obtained by Goldstein of the 2.7-μ band at 1273°K (solid line). Present values are given as points.

25
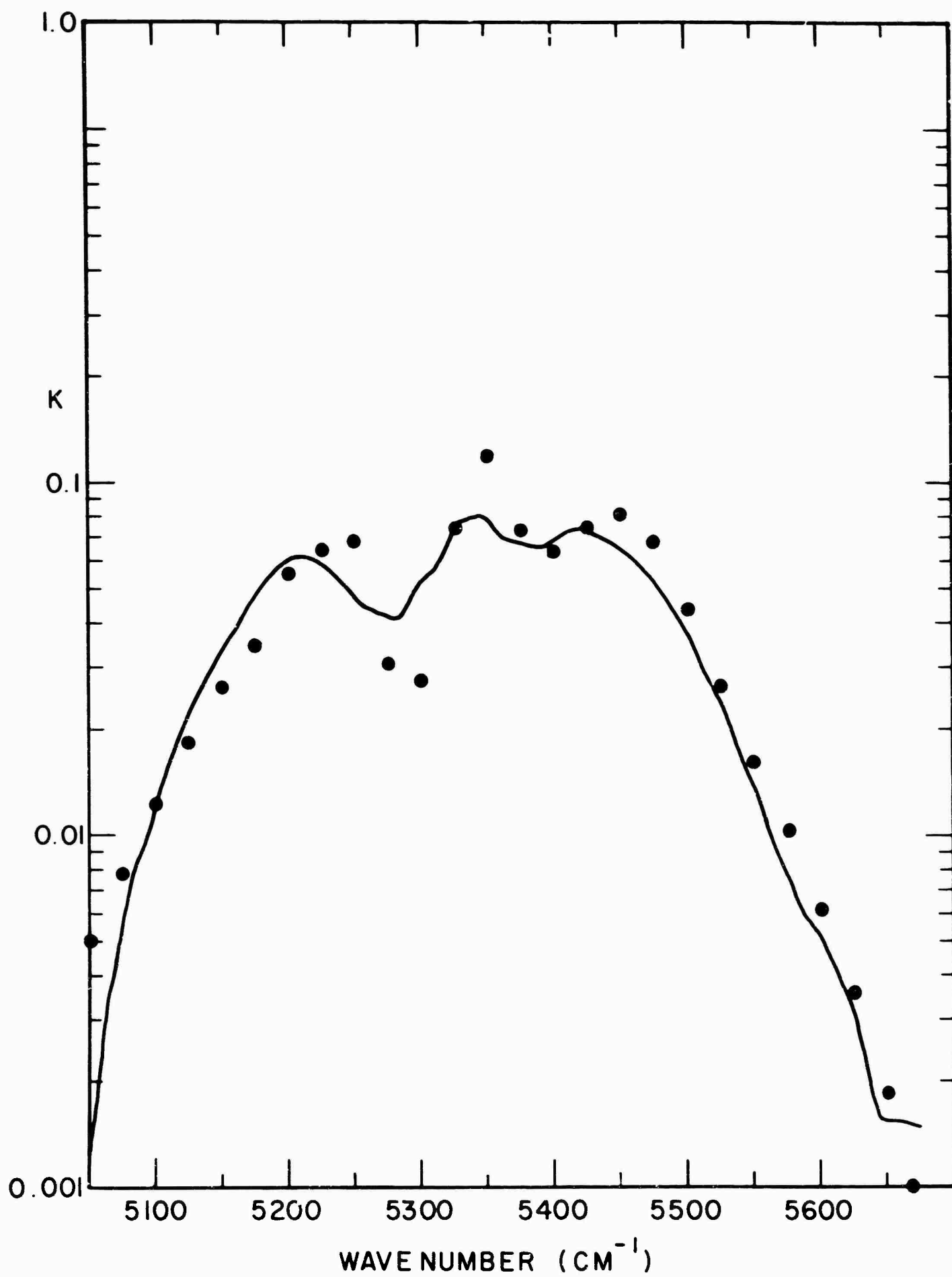
Figure 13. Comparison of absorption coefficients, obtained by Goldstein of the 1.9-μ band at 473°K (solid line). Present values are given as points.
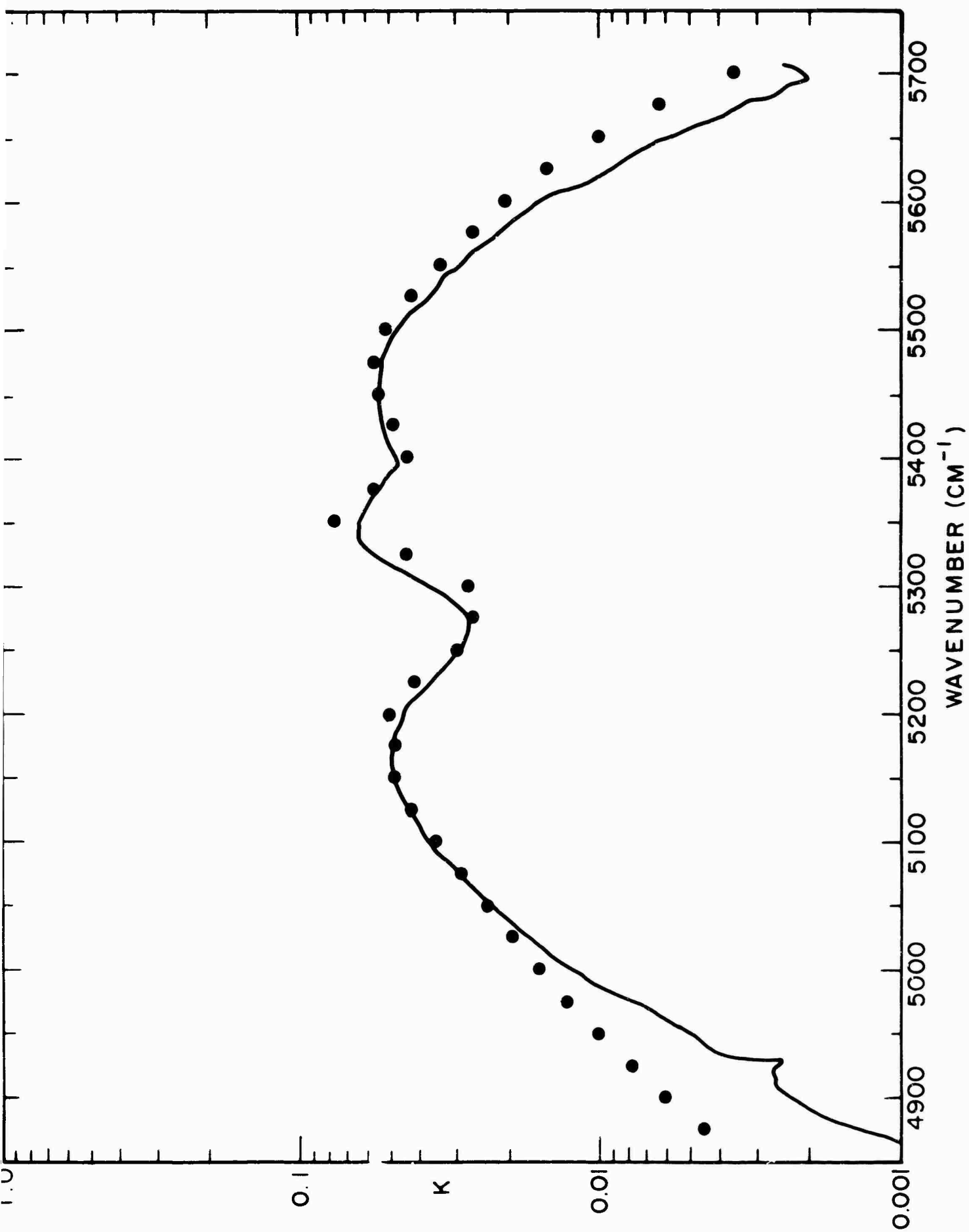
Figure 14. Graph of e of absorption coefficients, obtained by Goldstein of the 1.9-μ band at 573°K (of H₂O). Present values are given as points.

Figure ... Liquid ... absorption coefficients, obtained by Goldstein of the Labs ... at 1/3 °K
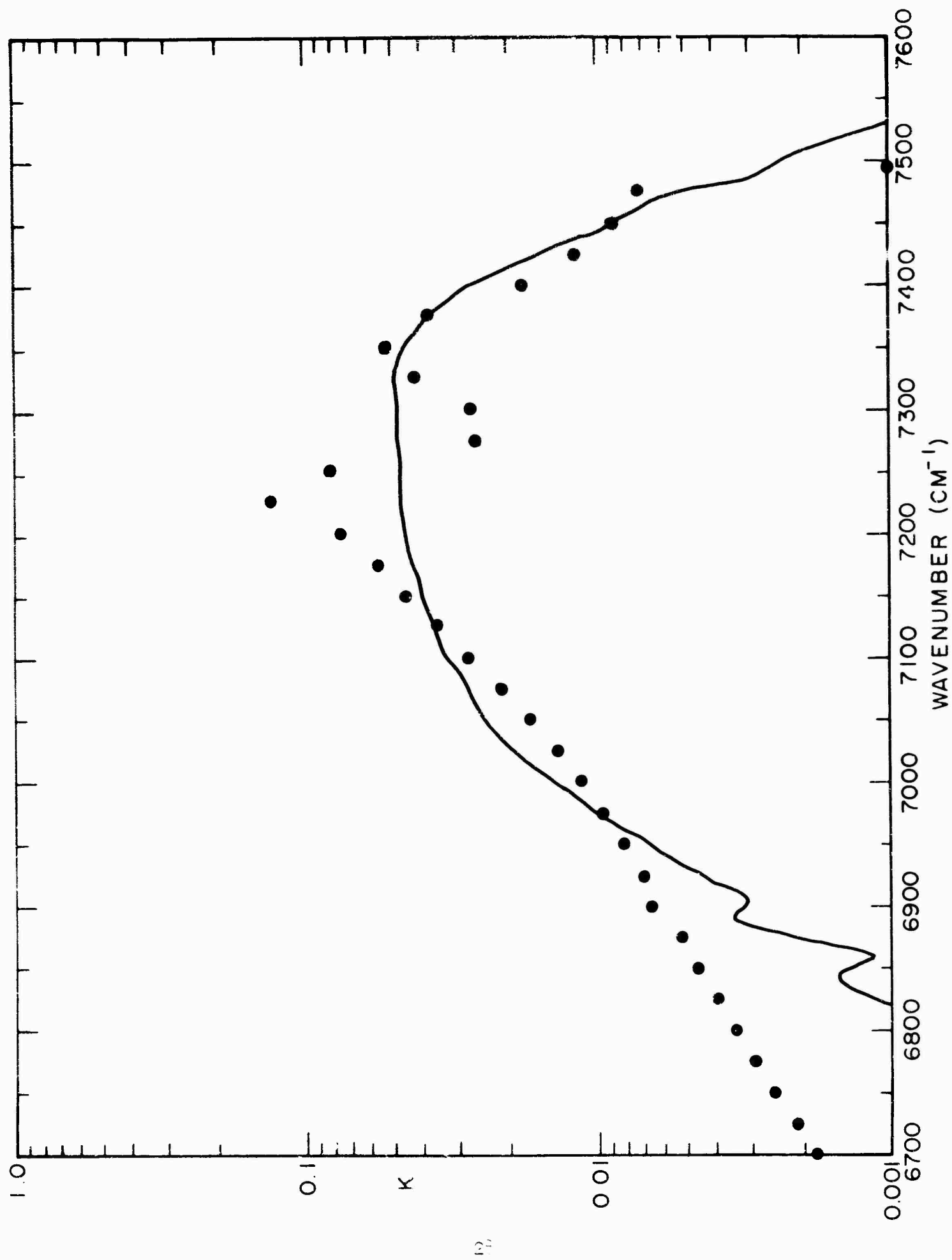
Figure 15. Comparison of absorption coefficients, obtained by Goldstein of the 1.4-μ band at 773°K (solid line). Present values are given as points.

29
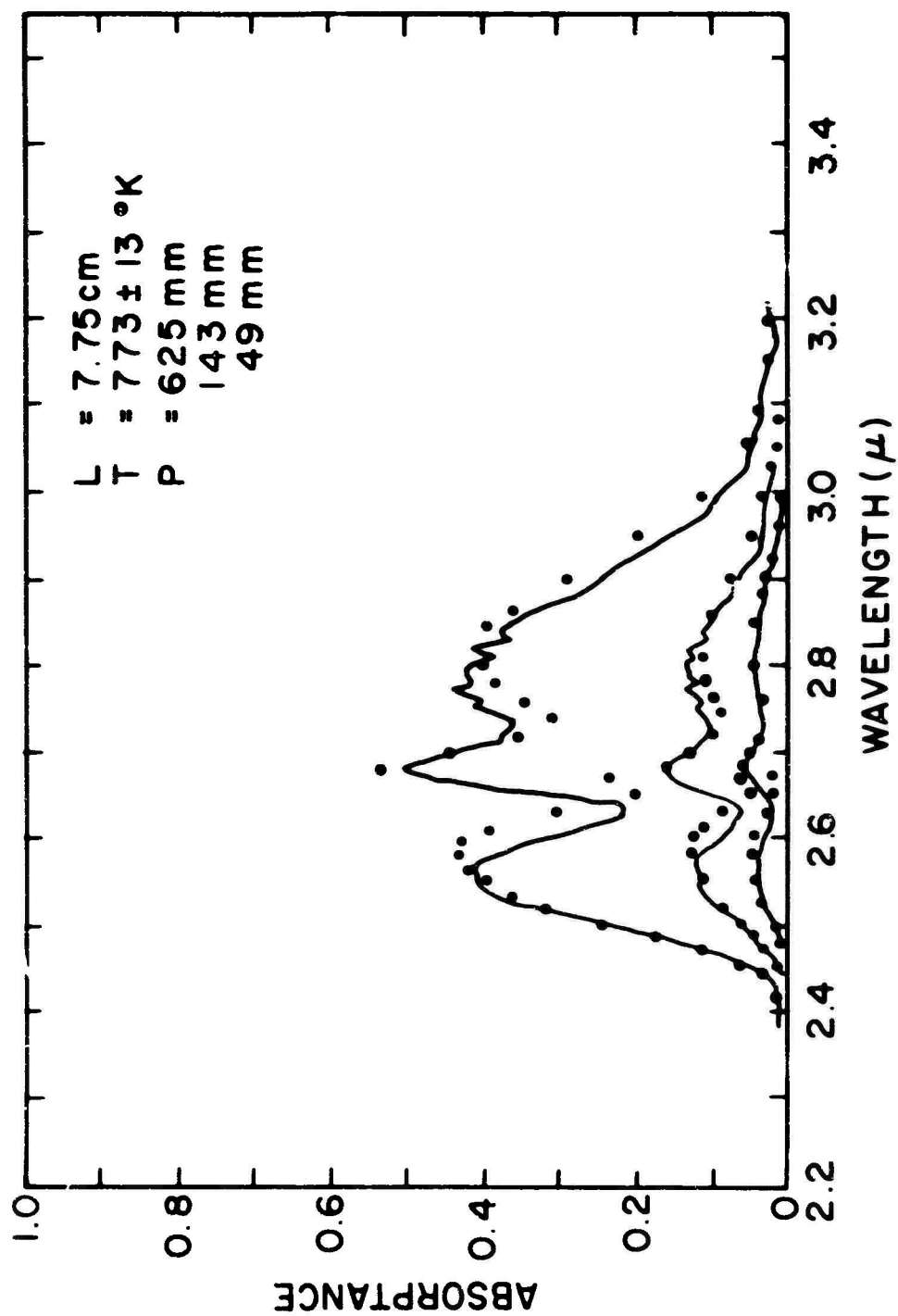
Figure 17. Comparison of measured and calculated emissivity of the 2.7-μ band. Solid lines are the measured spectra taken from Ref. 26, points are the present values.

30
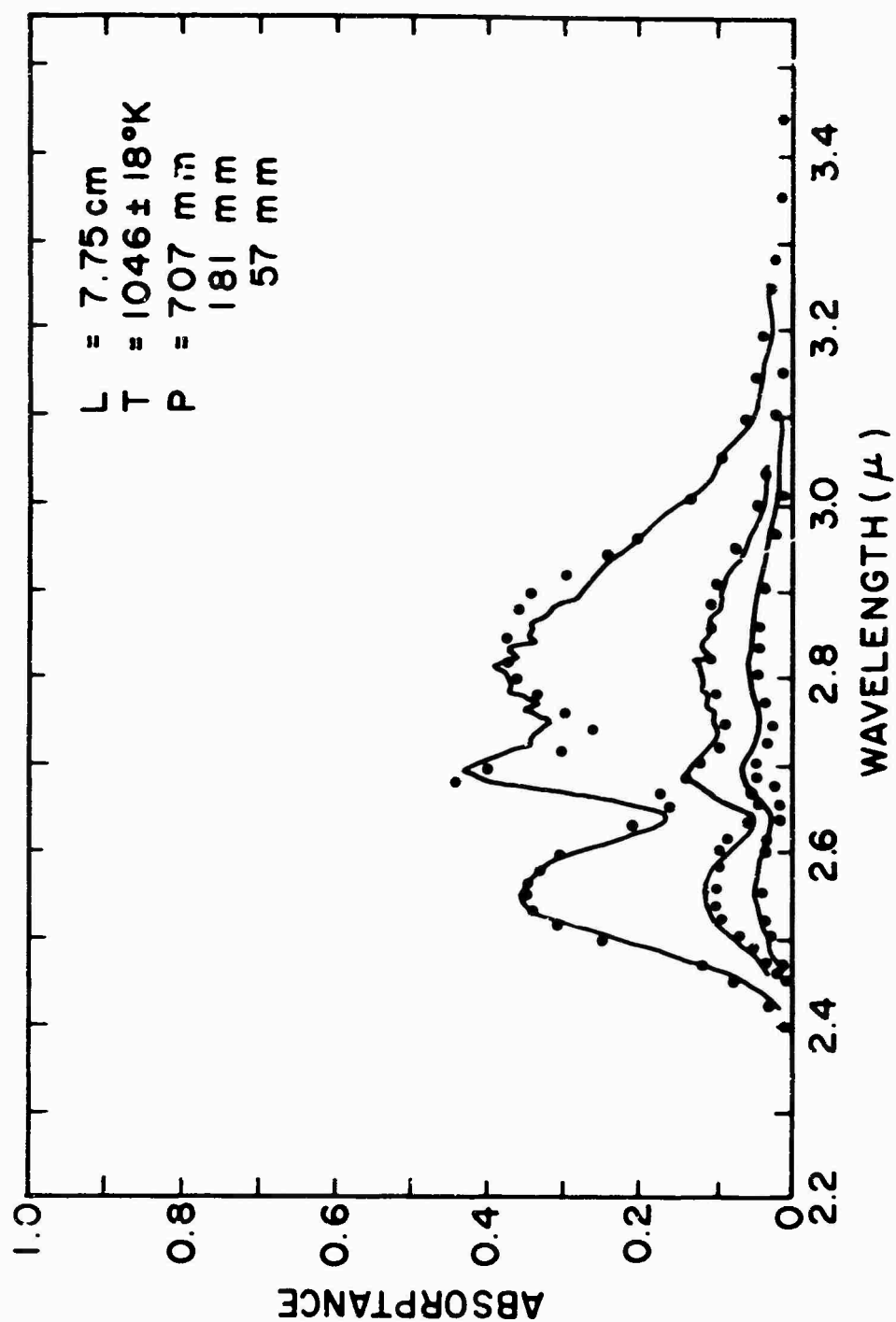
Figure 18. Comparison of measured and calculated emissivity of the 2.7-μ band. Solid lines are the measured spectra taken from Ref. 26, points are the present values.

31
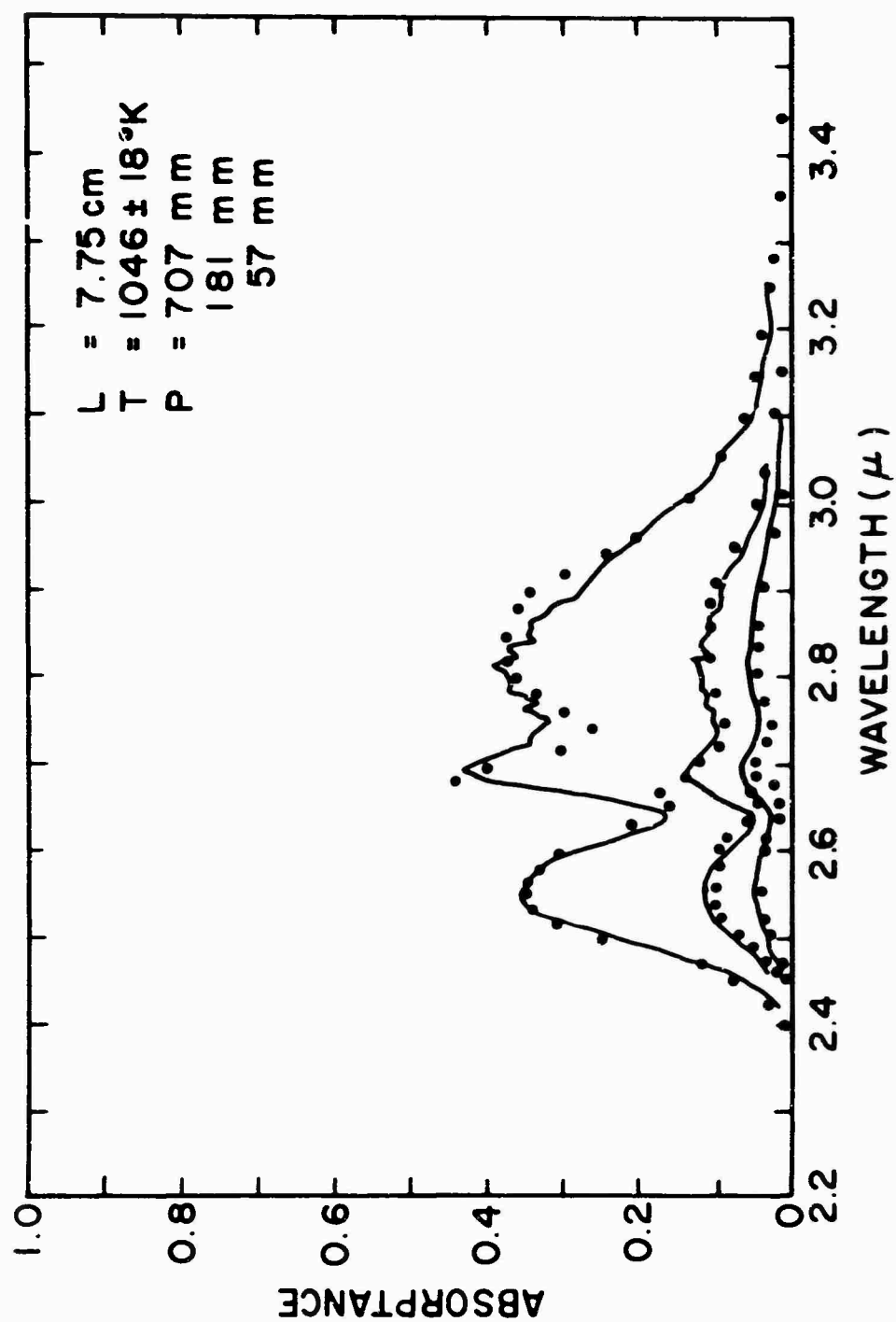
Figure 19. Comparison of measured and calculated emissivity of the 2.7-μ band. Solid lines are the measured spectra taken from Ref. 26, points are the present values.
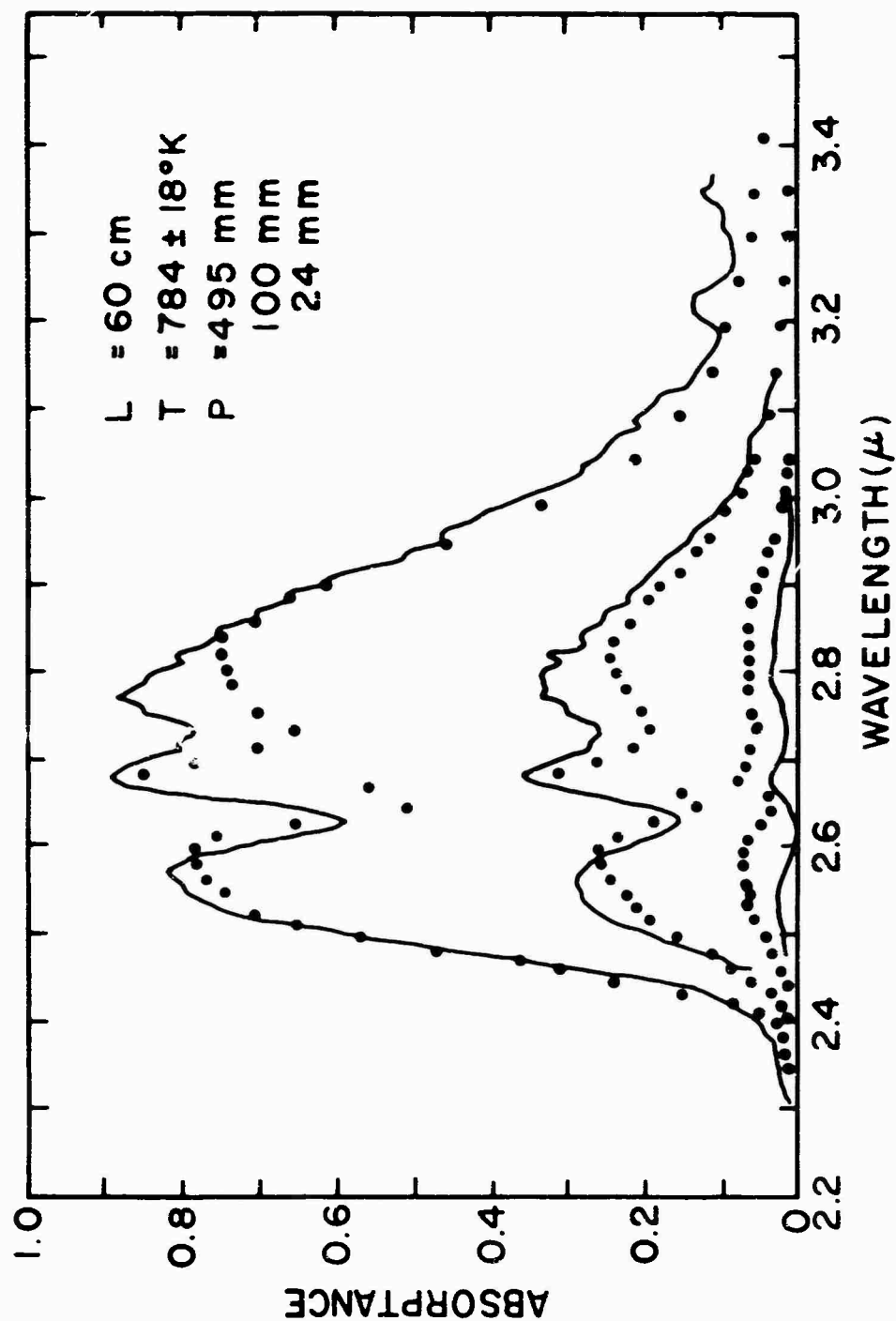
Figure 20. Comparison of measured and calculated emissivity of the 2.7-μ band. Solid lines are the measured spectra taken from Ref. 26, points are the present values.
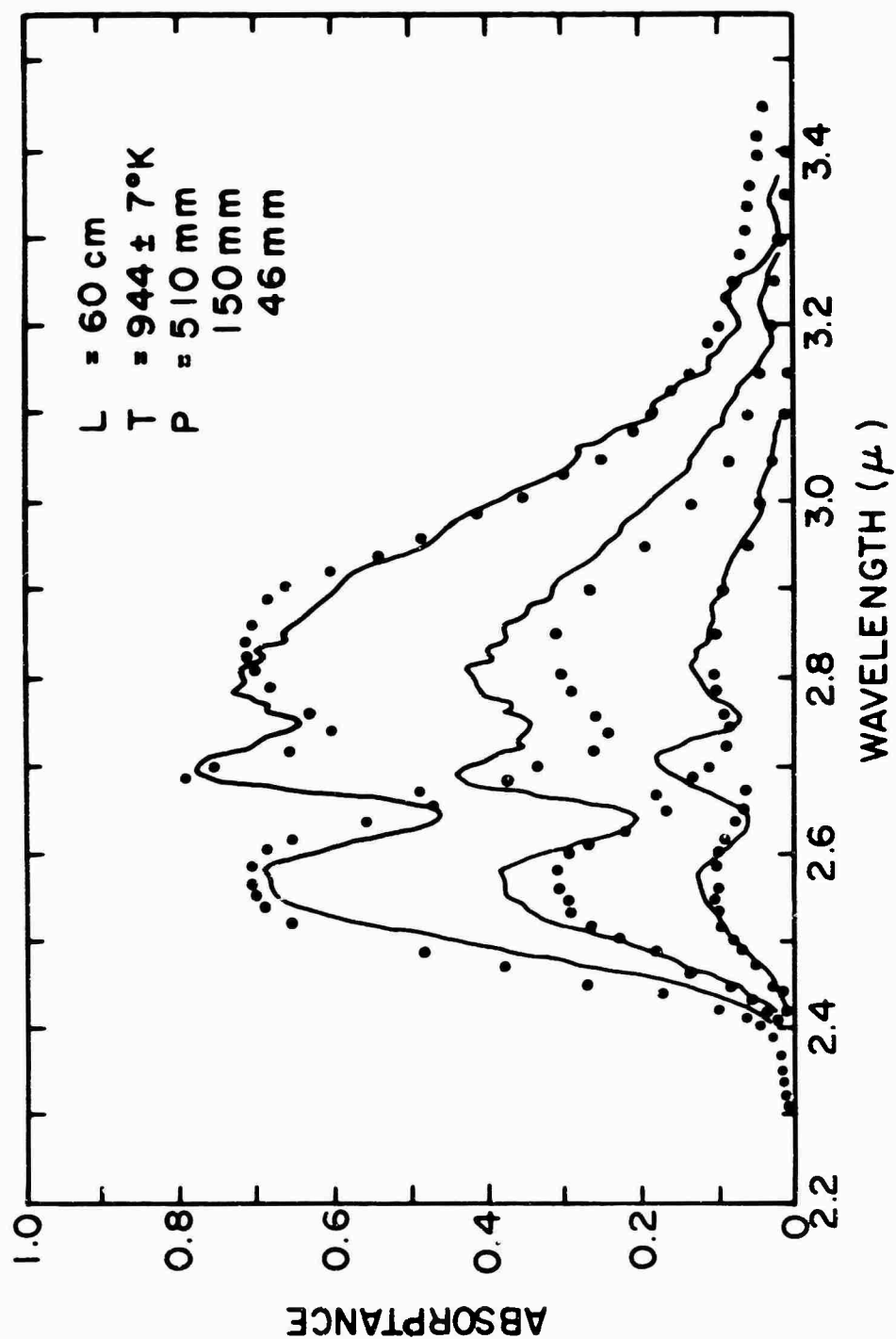
Figure 21. Comparison of measured and calculated emissivity of the 2.7-μ band. Solid lines are the measured spectra taken from Ref. 26, points are the present values.

34
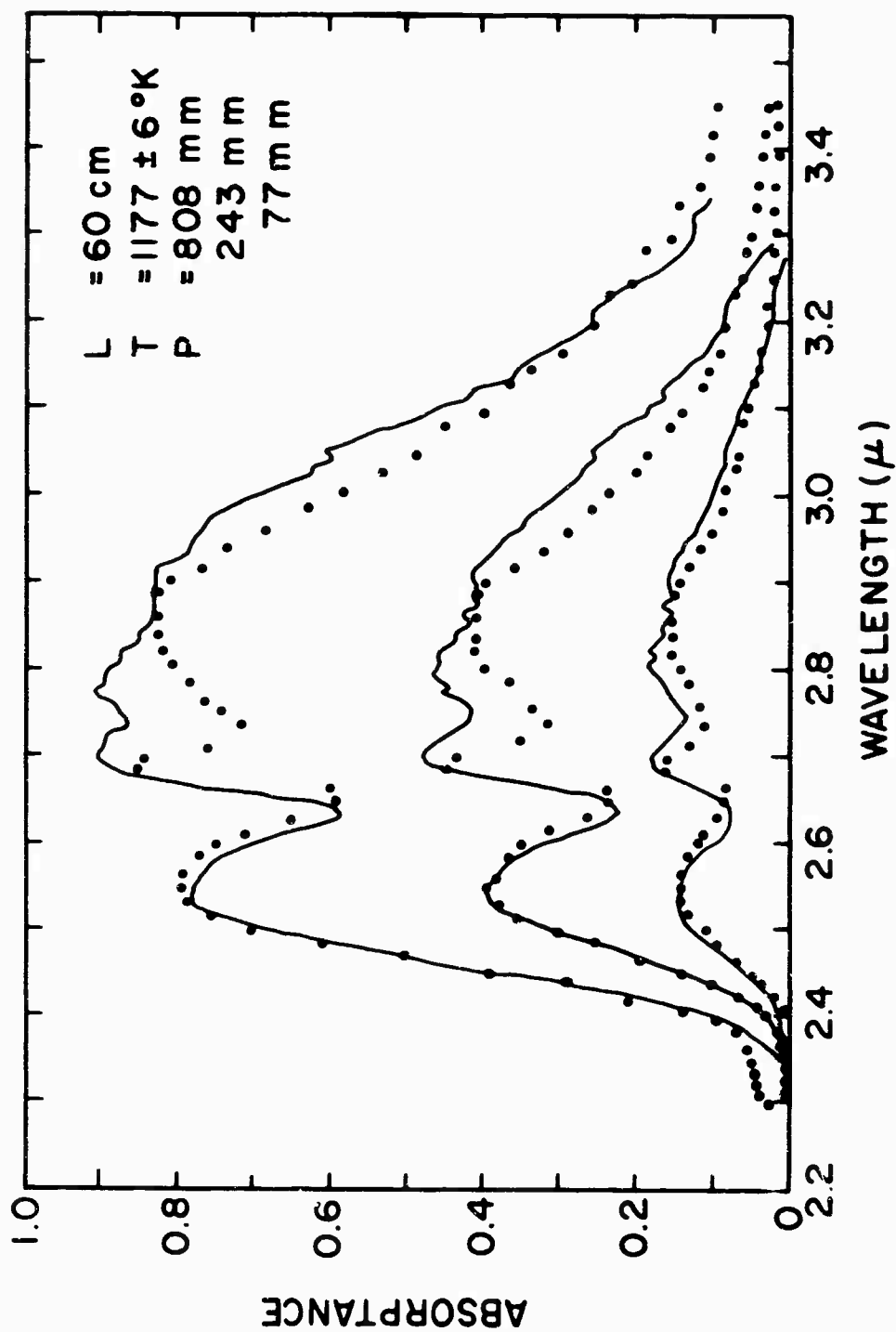
Figure 22. Comparison of measured and calculated emissivity of the 2.7-μ band. Solid lines are the measured spectra taken from Ref. 26, points are the present values.

H₂O 6.3 μ
T = 1111 °K
—— NELSON (p_T = 2 atm , 100 % H₂O , ℓ = 39 cm)
– – – PRESENT

WAVENUMBER (CM⁻¹)

WAVENUMBER (CM)
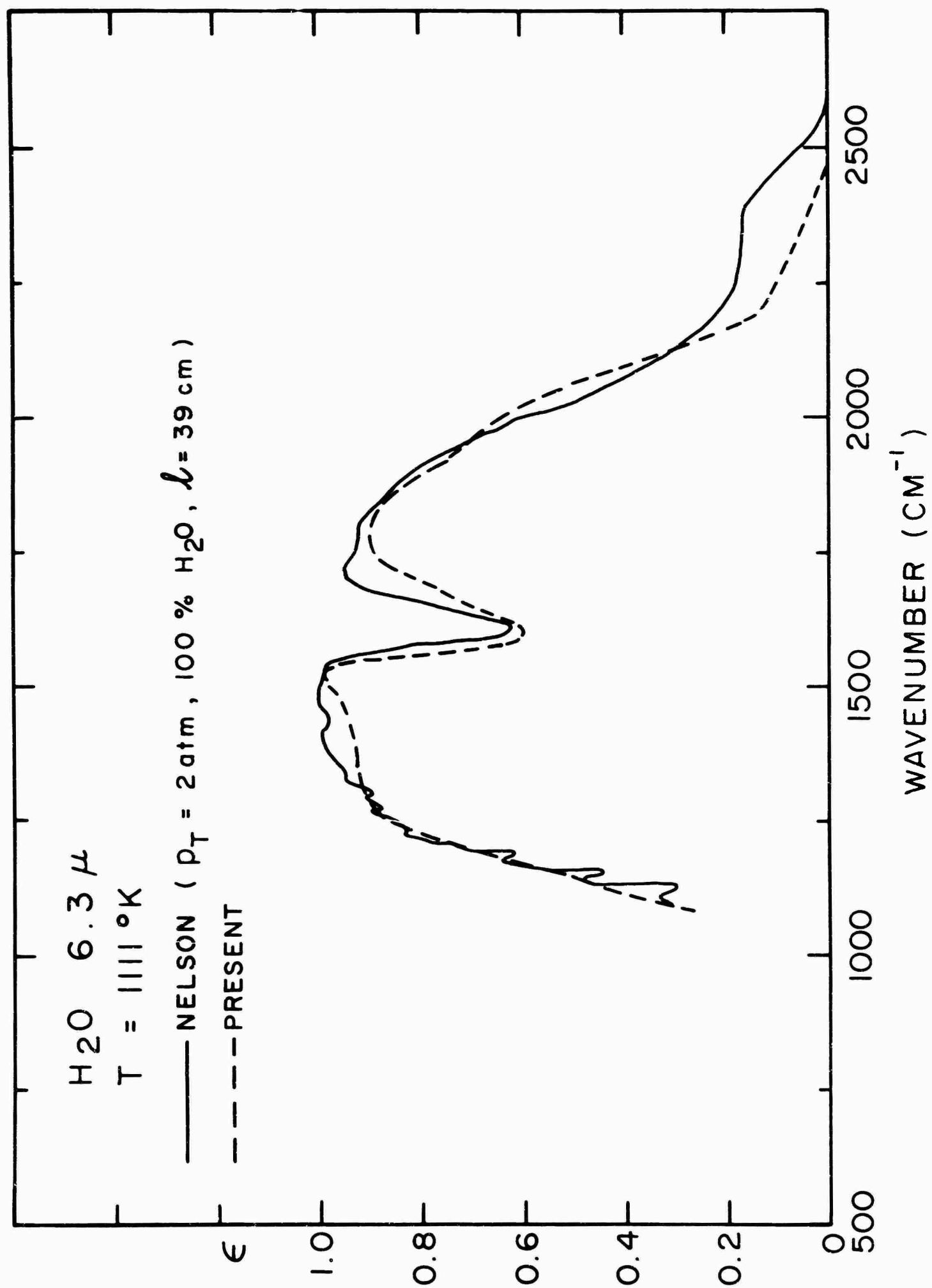
Figure 23. Comparison of measured and calculated emissivity.
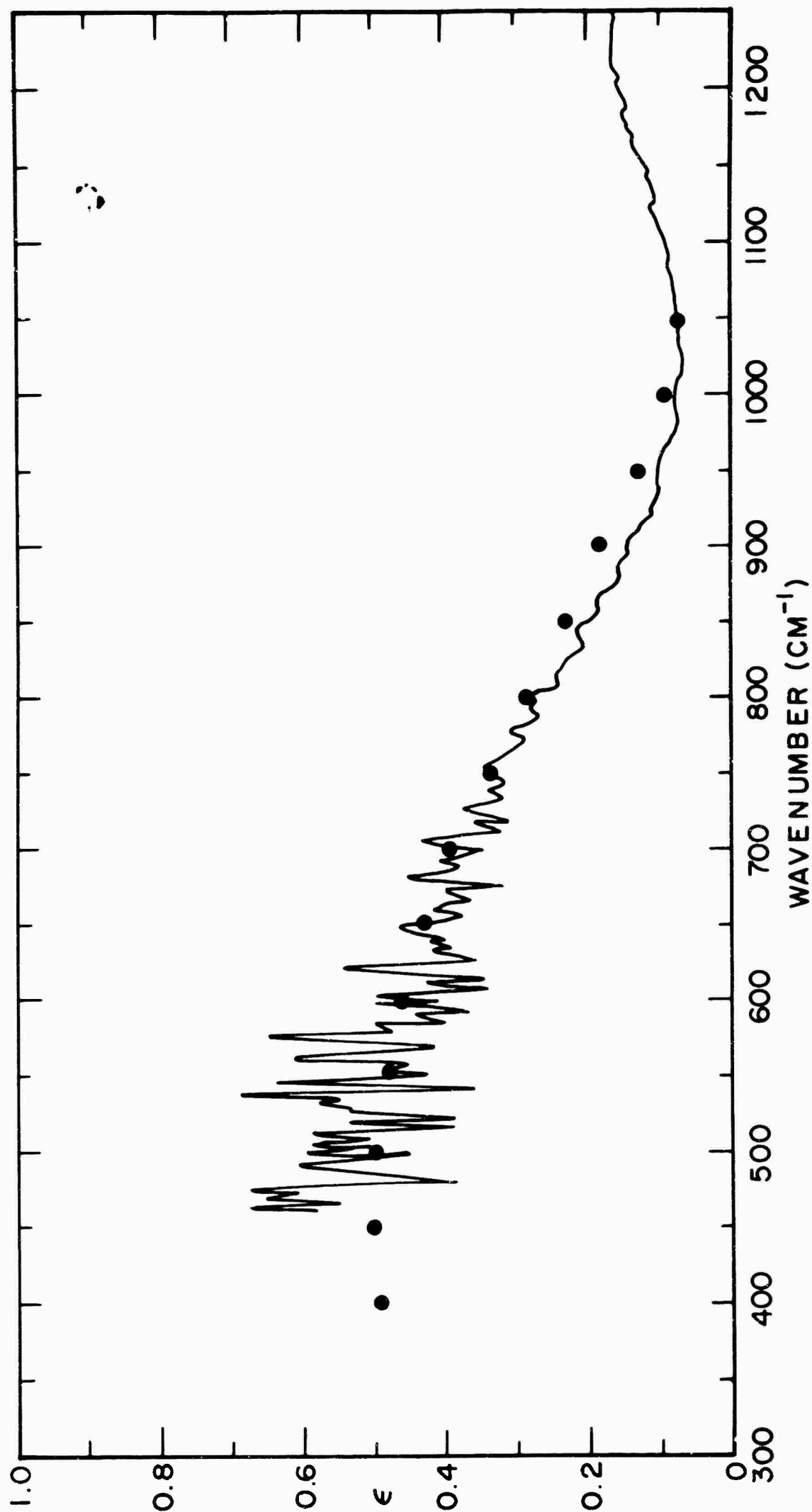
Figure 24. Comparison of measured and calculated emissivity of the rotational band from 500 cm^{-1} to 1050 cm^{-1}. Solid line is the measured spectrum by the present authors, points are the present values. (p_T = 1 atm, ℓ = 3.12 cm, T = 2200°K, u = 0.3 cm at STP).

Figure 25. Comparison of measured and calculated emissivity of the 1.9-μ band. Solid line is the measured spectrum by the present authors, points are the present values. (p_T = 1 atm, ℓ = 3.12 cm, T = 2200°K, u = 0.3 cm at STP).

Figure 26. Comparison of measured and calculated emissivity of the 1.4-μ band. Solid line is the measured spectrum by the present authors, points are the present values. ($p_T = 1$ atm, $\ell = 3.12$ cm, $T = 2200°$K, $u = 0.3$ cm at STP).
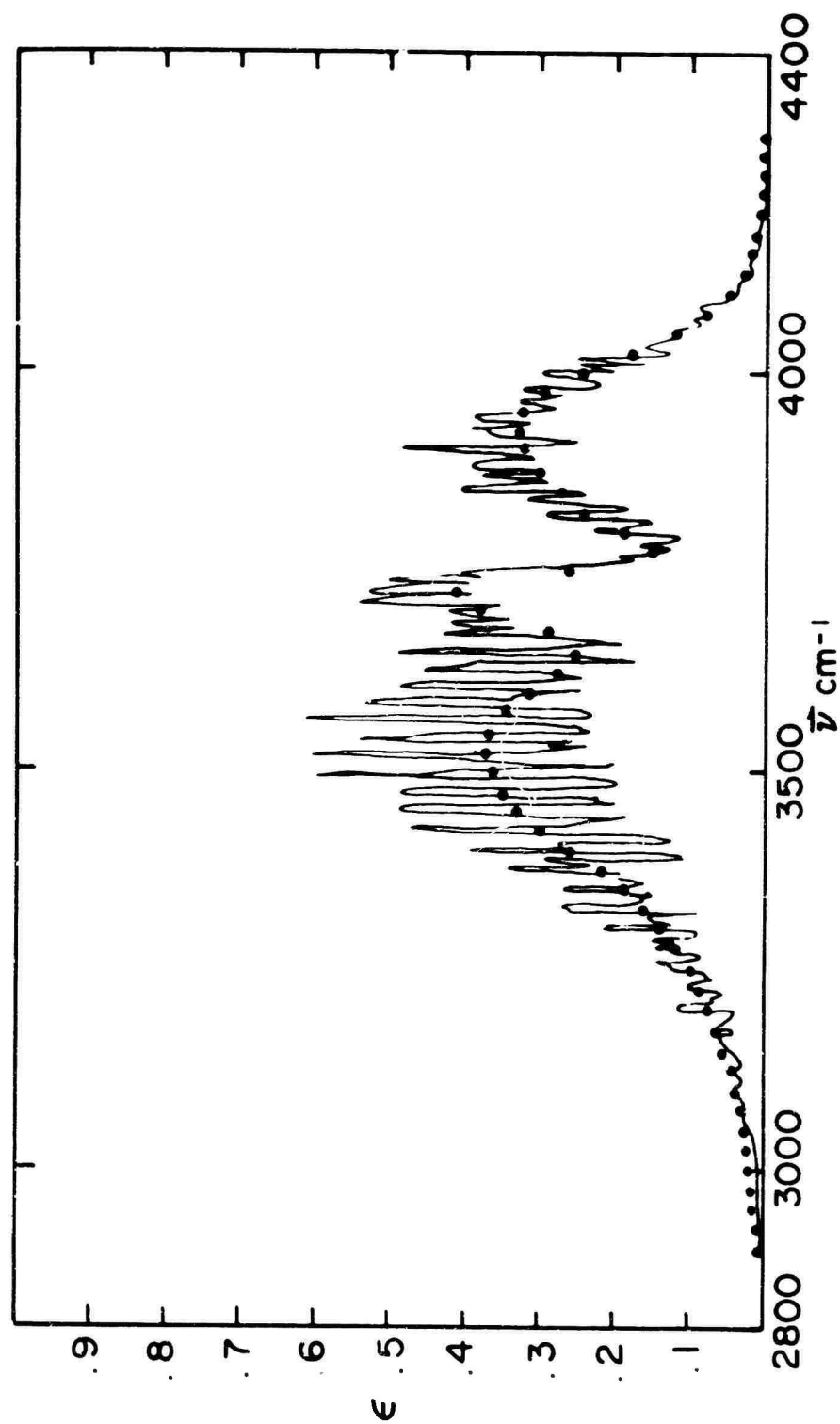
Figure 27. Comparison of measured and calculated emissivity of the 2.7-μ band. Solid line is the measured spectrum by Burch and Gryvnak. (p_T = 1 atm, T = 1200°K, u = 1.76 cm at STP, 100% H_2O).

TABLE II

ABSORPTION COEFFICIENTS OF H2O

K (PER CM AT STP)

1/CM	300 K	600 K	1000 K	1500 K	2000 K	2500 K	3000 K
50.0	.950E 00	.103E 00	.420E-01	.114E-01	.450E-02	.300E-02	.190E-02
75.0	.208E 01	.365E 00	.113E 00	.375E-01	.195E-01	.134E-01	.670E-02
100.0	.386E 01	.990E 00	.300E 00	.104E 00	.577E-01	.365E-01	.211E-01
125.0	.650E 01	.201E 01	.650E 00	.214E 00	.128E 00	.845E-01	.529E-01
150.0	.825E 01	.325E 01	.121E 01	.415E 00	.260E 00	.168E 00	.109E 00
175.0	.870E 01	.452E 01	.189E 01	.765E 00	.450E 00	.289E 00	.193E 00
200.0	.810E 01	.540E 01	.261E 01	.126E 01	.695E 00	.460E 00	.309E 00
225.0	.682E 01	.600E 01	.337E 01	.179E 01	.101E 01	.679E 00	.454E 00
250.0	.493E 01	.622E 01	.407E 01	.230E 01	.135E 01	.935E 00	.620E 00
275.0	.316E 01	.592E 01	.456E 01	.281E 01	.172E 01	.122E 01	.822E 00
300.0	.199E 01	.528E 01	.479E 01	.328E 01	.213E 01	.149E 01	.104E 01
325.0	.113E 01	.450E 01	.484E 01	.361E 01	.249E 01	.179E 01	.128E 01
350.0	.585E 00	.370E 01	.471E 01	.383E 01	.284E 01	.208E 01	.154E 01
375.0	.293E 00	.289E 01	.443E 01	.394E 01	.312E 01	.237E 01	.182E 01
400.0	.138E 00	.205E 01	.400E 01	.396E 01	.330E 01	.260E 01	.207E 01
425.0	.620E-01	.143E 01	.347E 01	.388E 01	.341E 01	.280E 01	.229E 01
450.0	.255E-01	.950E 00	.292E 01	.370E 01	.345E 01	.295E 01	.248E 01
475.0	.940E-02	.610E 00	.236E 01	.343E 01	.342E 01	.304E 01	.262E 01
500.0	.340E-02	.386E 00	.188E 01	.310E 01	.334E 01	.309E 01	.273E 01
525.0	.105E-02	.236E 00	.145E 01	.274E 01	.319E 01	.307E 01	.280E 01
550.0	.350E-03	.144E 00	.110E 01	.238E 01	.300E 01	.301E 01	.283E 01
575.0	.126E-03	.820E-01	.818E 00	.204E 01	.276E 01	.289E 01	.282E 01
600.0	.430E-04	.445E-01	.598E 00	.174E 01	.248E 01	.275E 01	.277E 01
625.0	.150E-04	.242E-01	.427E 00	.145E 01	.222E 01	.260E 01	.269E 01
650.0	.510E-05	.127E-01	.294E 00	.118E 01	.195E 01	.241E 01	.258E 01
675.0	.170E-05	.630E-02	.200E 00	.950E 00	.169E 01	.221E 01	.245E 01
700.0	.570E-06	.300E-02	.134E 00	.748E 00	.146E 01	.200E 01	.229E 01
725.0	.195E-06	.140E-02	.902E-01	.580E 00	.124E 01	.178E 01	.213E 01

ABSORPTION COEFFICIENTS OF H2O (CONT.D)
K (PER CM AT STP)

1/CM	300 K	600 K	1000 K	1500 K	2000 K	2500 K	3000 K
750.0	.680E-07	.620E-03	.590E-01	.443E 00	.103E 01	.156E 01	.196E 01
775.0	.385E-07	.275E-03	.450E-01	.330E 00	.845E 00	.136E 01	.177E 01
800.0	.670E-07	.113E-03	.355E-01	.242E 00	.695E 00	.117E 01	.159E 01
825.0	.113E-06	.500E-04	.289E-01	.174E 00	.560E 00	.100E 01	.143E 01
850.0	.195E-06	.230E-04	.245E-01	.123E 00	.450E 00	.855E 00	.126E 01
875.0	.328E-06	.103E-04	.214E-01	.100E 00	.357E 00	.718E 00	.111E 01
900.0	.560E-06	.460E-05	.189E-01	.830E-01	.278E 00	.595E 00	.955E 00
925.0	.950E-06	.205E-05	.174E-01	.730E-01	.239E 00	.492E 00	.825E 00
950.0	.160E-05	.140E-05	.166E-01	.665E-01	.211E 00	.405E 00	.705E 00
975.0	.275E-05	.350E-05	.165E-01	.630E-01	.195E 00	.352E 00	.600E 00
1000.0	.470E-05	.850E-05	.167E-01	.620E-01	.190E 00	.312E 00	.510E 00
1025.0	.810E-05	.215E-04	.175E-01	.630E-01	.191E 00	.289E 00	.425E 00
1050.0	.136E-04	.570E-04	.188E-01	.675E-01	.194E 00	.281E 00	.358E 00
1075.0	.235E-04	.150E-03	.208E-01	.745E-01	.202E 00	.283E 00	.329E 00
1100.0	.400E-04	.380E-03	.233E-01	.865E-01	.223E 00	.314E 00	.357E 00
1125.0	.680E-04	.950E-03	.268E-01	.122E 00	.260E 00	.380E 00	.449E 00
1150.0	.120E-03	.245E-02	.345E-01	.170E 00	.335E 00	.450E 00	.507E 00
1175.0	.200E-03	.620E-02	.555E-01	.228E 00	.410E 00	.505E 00	.568E 00
1200.0	.365E-03	.148E-01	.900E-01	.291E 00	.470E 00	.565E 00	.604E 00
1225.0	.680E-03	.330E-01	.152E 00	.355E 00	.497E 00	.580E 00	.632E 00
1250.0	.130E-02	.635E-01	.249E 00	.428E 00	.510E 00	.570E 00	.637E 00
1275.0	.250E-02	.123E 00	.340E 00	.463E 00	.522E 00	.555E 00	.608E 00
1300.0	.500E-02	.212E 00	.390E 00	.488E 00	.520E 00	.535E 00	.578E 00
1325.0	.103E-01	.285E 00	.435E 00	.497E 00	.510E 00	.515E 00	.554E 00
1350.0	.219E-01	.328E 00	.458E 00	.495E 00	.498E 00	.490E 00	.537E 00
1375.0	.485E-01	.345E 00	.462E 00	.489E 00	.485E 00	.480E 00	.520E 00
1400.0	.114E 00	.361E 00	.475E 00	.498E 00	.495E 00	.483E 00	.516E 00
1425.0	.249E 00	.460E 00	.505E 00	.540E 00	.520E 00	.500E 00	.514E 00
1450.0	.397E 00	.569E 00	.600E 00	.584E 00	.560E 00	.530E 00	.518E 00
1475.0	.418E 00	.627E 00	.660E 00	.630E 00	.595E 00	.560E 00	.530E 00

ABSORPTION COEFFICIENTS OF H2O (CONT.D)

K (PER CM AT STP)

1/CM	300 K	600 K	1000 K	1500 K	2000 K	2500 K	3000 K
1500.0	.108E 01	.125E 01	.115E 01	.894E 00	.719E 00	.603E 00	.525E 00
1525.0	.165E 01	.211E 01	.135E 01	.757E 00	.549E 00	.466E 00	.430E 00
1550.0	.142E 01	.675E 00	.400E 00	.310E 00	.280E 00	.270E 00	.277E 00
1575.0	.113E 00	.135E 00	.121E 00	.122E 00	.140E 00	.160E 00	.173E 00
1600.0	.275E-01	.538E-01	.769E-01	.938E-01	.104E 00	.110E 00	.110E 00
1625.0	.123E 00	.910E-01	.935E-01	.101E 00	.960E-01	.109E 00	.111E 00
1650.0	.730E 00	.199E 00	.135E 00	.120E 00	.109E 00	.120E 00	.135E 00
1675.0	.149E 01	.346E 00	.179E 00	.151E 00	.130E 00	.140E 00	.156E 00
1700.0	.162E 01	.433E 00	.226E 00	.192E 00	.160E 00	.164E 00	.173E 00
1725.0	.135E 01	.458E 00	.290E 00	.237E 00	.201E 00	.190E 00	.191E 00
1750.0	.740E 00	.467E 00	.370E 00	.284E 00	.240E 00	.218E 00	.209E 00
1775.0	.420E 00	.443E 00	.400E 00	.306E 00	.275E 00	.240E 00	.226E 00
1800.0	.250E 00	.393E 00	.400E 00	.312E 00	.290E 00	.256E 00	.242E 00
1825.0	.147E 00	.319E 00	.350E 00	.300E 00	.291E 00	.262E 00	.250E 00
1850.0	.910E-01	.252E 00	.293E 00	.284E 00	.276E 00	.256E 00	.247E 00
1875.0	.580E-01	.198E 00	.244E 00	.252E 00	.248E 00	.245E 00	.238E 00
1900.0	.370E-01	.153E 00	.200E 00	.220E 00	.222E 00	.225E 00	.222E 00
1925.0	.244E-01	.118E 00	.162E 00	.192E 00	.200E 00	.205E 00	.206E 00
1950.0	.162E-01	.900E-01	.133E 00	.166E 00	.180E 00	.188E 00	.185E 00
1975.0	.112E-01	.665E-01	.107E 00	.142E 00	.158E 00	.162E 00	.166E 00
2000.0	.780E-02	.490E-01	.870E-01	.121E 00	.138E 00	.143E 00	.147E 00
2025.0	.540E-02	.352E-01	.670E-01	.981E-01	.116E 00	.123E 00	.129E 00
2050.0	.380E-02	.252E-01	.515E-01	.790E-01	.990E-01	.102E 00	.111E 00
2075.0	.260E-02	.179E-01	.390E-01	.605E-01	.830E-01	.870E-01	.960E-01
2100.0	.180E-02	.123E-01	.290E-01	.471E-01	.700E-01	.730E-01	.840E-01
2125.0	.127E-02	.850E-02	.213E-01	.359E-01	.585E-01	.630E-01	.725E-01
2150.0	.880E-03	.680E-02	.155E-01	.268E-01	.480E-01	.530E-01	.628E-01
2175.0	.620E-03	.400E-02	.113E-01	.201E-01	.395E-01	.460E-01	.530E-01
2200.0	.480E-03	.290E-02	.810E-02	.161E-01	.325E-01	.395E-01	.455E-01
2225.0	.405E-03	.240E-02	.620E-02	.129E-01	.267E-01	.340E-01	.398E-01

ABSORPTION COEFFICIENTS OF H2O (CONT.D)

K (PER CM AT STP)

1/CM	300 K	600 K	1000 K	1500 K	2000 K	2500 K	3000 K
2250.0	.386E-03	.200E-02	.520E-02	.103E-01	.218E-01	.292E-01	.350E-01
2275.0	.385E-03	.180E-02	.440E-02	.910E-02	.181E-01	.253E-01	.312E-01
2300.0	.390E-03	.160E-02	.380E-02	.810E-02	.160E-01	.227E-01	.290E-01
2325.0	.400E-03	.150E-02	.340E-02	.760E-02	.145E-01	.209E-01	.275E-01
2350.0	.415E-03	.140E-02	.300E-02	.720E-02	.132E-01	.191E-01	.267E-01
2375.0	.430E-03	.140E-02	.280E-02	.690E-02	.125E-01	.177E-01	.259E-01
2400.0	.455E-03	.130E-02	.260E-02	.670E-02	.118E-01	.168E-01	.252E-01
2425.0	.485E-03	.130E-02	.250E-02	.660E-02	.111E-01	.164E-01	.251E-01
2450.0	.515E-03	.130E-02	.240E-02	.650E-02	.105E-01	.163E-01	.249E-01
2475.0	.550E-03	.130E-02	.230E-02	.650E-02	.102E-01	.165E-01	.247E-01
2500.0	.595E-03	.120E-02	.230E-02	.640E-02	.100E-01	.167E-01	.248E-01
2525.0	.640E-03	.120E-02	.230E-02	.640E-02	.100E-01	.172E-01	.249E-01
2550.0	.680E-03	.120E-02	.230E-02	.640E-02	.100E-01	.179E-01	.251E-01
2575.0	.740E-03	.130E-02	.230E-02	.640E-02	.102E-01	.187E-01	.253E-01
2600.0	.795E-03	.130E-02	.240E-02	.650E-02	.105E-01	.196E-01	.258E-01
2625.0	.855E-03	.130E-02	.250E-02	.660E-02	.106E-01	.205E-01	.263E-01
2650.0	.910E-03	.130E-02	.250E-02	.670E-02	.114E-01	.214E-01	.270E-01
2675.0	.990E-03	.140E-02	.260E-02	.680E-02	.120E-01	.229E-01	.280E-01
2700.0	.106E-02	.140E-02	.270E-02	.710E-02	.126E-01	.248E-01	.295E-01
2725.0	.113E-02	.150E-02	.280E-02	.740E-02	.135E-01	.268E-01	.318E-01
2750.0	.122E-02	.160E-02	.290E-02	.760E-02	.149E-01	.282E-01	.343E-01
2775.0	.130E-02	.170E-02	.300E-02	.800E-02	.169E-01	.308E-01	.378E-01
2800.0	.145E-02	.180E-02	.310E-02	.860E-02	.191E-01	.335E-01	.417E-01
2825.0	.159E-02	.190E-02	.330E-02	.920E-02	.212E-01	.365E-01	.459E-01
2850.0	.174E-02	.200E-02	.350E-02	.100E-01	.240E-01	.405E-01	.500E-01
2875.0	.195E-02	.210E-02	.370E-02	.109E-01	.272E-01	.450E-01	.550E-01
2900.0	.213E-02	.230E-02	.400E-02	.122E-01	.305E-01	.500E-01	.602E-01
2925.0	.238E-02	.250E-02	.440E-02	.137E-01	.348E-01	.557E-01	.665E-01
2950.0	.260E-02	.270E-02	.480E-02	.157E-01	.398E-01	.620E-01	.735E-01
2975.0	.282E-02	.300E-02	.540E-02	.181E-01	.450E-01	.690E-01	.801E-01

ABSORPTION COEFFICIENTS OF H2O (CONT.D)

K (PER CM AT STP)

1/CM	300 K	600 K	1000 K	1500 K	2000 K	2500 K	3000 K
3000.0	.295E-02	.330E-02	.590E-02	.211E-01	.510E-01	.765E-01	.885E-01
3025.0	.310E-02	.370E-02	.660E-02	.247E-01	.590E-01	.855E-01	.970E-01
3050.0	.340E-02	.400E-02	.760E-02	.290E-01	.665E-01	.945E-01	.106E 00
3075.0	.730E-02	.450E-02	.870E-02	.347E-01	.760E-01	.104E 00	.117E 00
3100.0	.900E-02	.480E-02	.100E-01	.420E-01	.880E-01	.117E 00	.129E 00
3125.0	.100E-02	.510E-02	.117E-01	.498E-01	.995E-01	.129E 00	.142E 00
3150.0	.640E-03	.550E-02	.138E-01	.608E-01	.112E 00	.144E 00	.155E 00
3175.0	.160E-02	.600E-02	.167E-01	.725E-01	.128E 00	.160E 00	.170E 00
3200.0	.330E-02	.700E-02	.202E-01	.870E-01	.147E 00	.178E 00	.187E 00
3225.0	.410E-02	.860E-02	.252E-01	.101E 00	.166E 00	.199E 00	.202E 00
3250.0	.410E-02	.103E-01	.321E-01	.119E 00	.185E 00	.219E 00	.220E 00
3275.0	.290E-02	.129E-01	.410E-01	.139E 00	.205E 00	.240E 00	.241E 00
3300.0	.220E-02	.161E-01	.540E-01	.162E 00	.226E 00	.253E 00	.262E 00
3325.0	.220E-02	.212E-01	.710E-01	.187E 00	.246E 00	.265E 00	.280E 00
3350.0	.250E-02	.285E-01	.980E-01	.214E 00	.270E 00	.278E 00	.293E 00
3375.0	.310E-02	.385E-01	.135E 00	.245E 00	.288E 00	.285E 00	.302E 00
3400.0	.420E-02	.540E-01	.187E 00	.278E 00	.302E 00	.291E 00	.308E 00
3425.0	.600E-02	.770E-01	.251E 00	.311E 00	.312E 00	.293E 00	.300E 00
3450.0	.940E-02	.117E 00	.330E 00	.341E 00	.312E 00	.291E 00	.290E 00
3475.0	.165E-01	.173E 00	.370E 00	.350E 00	.305E 00	.286E 00	.272E 00
3500.0	.360E-01	.258E 00	.390E 00	.343E 00	.284E 00	.270E 00	.265E 00
3525.0	.720E-01	.375E 00	.400E 00	.328E 00	.264E 00	.255E 00	.241E 00
3550.0	.133E 00	.401E 00	.400E 00	.309E 00	.245E 00	.237E 00	.222E 00
3575.0	.215E 00	.401E 00	.378E 00	.279E 00	.225E 00	.215E 00	.208E 00
3600.0	.318E 00	.392E 00	.330E 00	.243E 00	.200E 00	.202E 00	.201E 00
3625.0	.442E 00	.320E 00	.260E 00	.216E 00	.188E 00	.196E 00	.210E 00
3650.0	.473E 00	.255E 00	.225E 00	.206E 00	.188E 00	.198E 00	.213E 00
3675.0	.448E 00	.340E 00	.270E 00	.250E 00	.207E 00	.197E 00	.200E 00
3700.0	.328E 00	.518E 00	.460E 00	.3:9E 00	.229E 00	.172E 00	.150E 00
3725.0	.317E 00	.831E 00	.580E 00	.295E 00	.175E 00	.113E 00	.113E 00

ABSORPTION COEFFICIENTS OF H2O (CONT.D)

K (PER CM AT STP)

1/CM	300 K	600 K	1000 K	1500 K	2000 K	2500 K	3000 K
3750.0	.181E 01	.196E 00	.120E 00	.111E 00	.115E 00	.102E 00	.108E 00
3775.0	.136E 00	.124E 00	.116E 00	.110E 00	.950E-01	.985E-01	.109E 00
3800.0	.455E 00	.298E 00	.171E 00	.114E 00	.996E-01	.105E 00	.122E 00
3825.0	.760E 00	.503E 00	.251E 00	.131E 00	.116E 00	.118E 00	.136E 00
3850.0	.836E 00	.584E 00	.300E 00	.154E 00	.141E 00	.133E 00	.154E 00
3875.0	.650E 00	.568E 00	.335E 00	.191E 00	.168E 00	.151E 00	.177E 00
3900.0	.285E 00	.500E 00	.355E 00	.232E 00	.200E 00	.175E 00	.197E 00
3925.0	.117E 00	.400E 00	.356E 00	.269E 00	.219E 00	.186E 00	.209E 00
3950.0	.460E-01	.300E 00	.340E 00	.269E 00	.213E 00	.190E 00	.207E 00
3975.0	.183E-01	.205E 00	.295E 00	.223E 00	.182E 00	.183E 00	.190E 00
4000.0	.730E-02	.135E 00	.212E 00	.168E 00	.148E 00	.160E 00	.161E 00
4025.0	.310E-02	.790E-01	.138E 00	.123E 00	.118E 00	.129E 00	.132E 00
4050.0	.140E-02	.415E-01	.799E-01	.898E-01	.930E-01	.103E 00	.104E 00
4075.0	.640E-03	.197E-01	.440E-01	.625E-01	.755E-01	.839E-01	.860E-01
4100.0	.330E-03	.860E-02	.235E-01	.438E-01	.580E-01	.670E-01	.710E-01
4125.0	.153E-03	.360E-02	.126E-01	.296E-01	.460E-01	.540E-01	.598E-01
4150.0	.720E-04	.150E-02	.690E-02	.201E-01	.355E-01	.435E-01	.499E-01
4175.0	.345E-04	.640E-03	.410E-02	.140E-01	.270E-01	.353E-01	.418E-01
4200.0	.165E-04	.260E-03	.260E-02	.104E-01	.200E-01	.286E-01	.348E-01
4225.0	.770E-05	.112E-03	.200E-02	.800E-02	.151E-01	.232E-01	.287E-01
4250.0	.365E-05	.480E-04	.170E-02	.690E-02	.122E-01	.191E-01	.236E-01
4275.0	.170E-05	.210E-04	.150E-02	.600E-02	.100E-01	.157E-01	.189E-01
4300.0	.820E-06	.900E-05	.140E-02	.540E-02	.880E-02	.134E-01	.150E-01
4325.0	.375E-06	.380E-05	.130E-02	.480E-02	.790E-02	.118E-01	.126E-01
4350.0	.180E-06	.165E-05	.120E-02	.430E-02	.720E-02	.107E-01	.119E-01
4375.0	.890E-07	.720E-06	.110E-02	.390E-02	.680E-02	.102E-01	.118E-01
4400.0	.420E-07	.300E-06	.100E-02	.370E-02	.660E-02	.970E-02	.123E-01
4425.0	.200E-07	.130E-06	.100E-02	.340E-02	.660E-02	.930E-02	.128E-01
4450.0	.100E-07	.570E-07	.100E-02	.330E-02	.660E-02	.920E-02	.134E-01
4475.0	.400E-08	.250E-07	.900E-03	.320E-02	.680E-02	.930E-02	.142E-01

ABSORPTION COEFFICIENTS OF H2O (CONT.D)
K (PER CM AT STP)

1/CM	300 K	600 K	1000 K	1500 K	2000 K	2500 K	3000 K
4500.0	.200E-08	.110E-07	.900E-03	.320E-02	.700E-02	.960E-02	.151E-01
4525.0	.100E-08	.500E-08	.900E-03	.330E-02	.720E-02	.103E-01	.162E-01
4550.0	.400E-09	.550E-08	.900E-03	.330E-02	.750E-02	.108E-01	.173E-01
4575.0	.200E-09	.110E-07	.900E-03	.340E-02	.790E-02	.115E-01	.187E-01
4600.0	.100E-09	.230E-07	.900E-03	.360E-02	.840E-02	.125E-01	.202E-01
4625.0	.100E-09	.470E-07	.100E-02	.380E-02	.910E-02	.139E-01	.223E-01
4650.0	.100E-09	.100E-06	.100E-02	.410E-02	.100E-01	.162E-01	.246E-01
4675.0	.300E-09	.210E-06	.110E-02	.450E-02	.108E-01	.196E-01	.270E-01
4700.0	.900E-09	.430E-06	.130E-02	.530E-02	.119E-01	.225E-01	.300E-01
4725.0	.200E-08	.880E-06	.150E-02	.630E-02	.132E-01	.260E-01	.338E-01
4750.0	.500E-08	.175E-05	.170E-02	.760E-02	.149E-01	.292E-01	.370E 1
4775.0	.100E-07	.370E-05	.210E-02	.105E-01	.170E-01	.322E-01	.399E 1
4800.0	.250E-07	.750E-05	.260E-02	.136E-01	.200E-01	.352E-01	.422E-01
4825.0	.630E-07	.153E-04	.370E-02	.170E-01	.233E-01	.379E-01	.440E-01
4850.0	.165E-06	.315E-04	.500E-02	.202E-01	.273E-01	.403E-01	.458E-01
4875.0	.415E-06	.630E-04	.660E-02	.241E-01	.320E-01	.426E-01	.465E-01
4900.0	.107E-05	.145E-03	.880E-02	.279E-01	.375E-01	.450E-01	.473E-01
4925.0	.275E-05	.290E-03	.113E-01	.312E-01	.420E-01	.470E-01	.478E-01
4950.0	.670E-05	.600E-03	.145E-01	.348E-01	.459E-01	.485E-01	.478E-01
4975.0	.165E-04	.145E-02	.180E-01	.381E-01	.480E-01	.490E-01	.473E-01
5000.0	.420E-04	.290E-02	.220E-01	.417E-01	.490E-01	.490E-01	.460E-01
5025.0	.115E-03	.530E-02	.261E-01	.447E-01	.489E-01	.472E-01	.447E-01
5050.0	.320E-03	.860E-02	.308E-01	.480E-01	.480E-01	.455E-01	.430E-01
5075.0	.820E-03	.130E-01	.360E-01	.500E-01	.470E-01	.435E-01	.415E-01
5100.0	.200E-02	.198E-01	.418E-01	.507E-01	.455E-01	.418E-01	.400E-01
5125.0	.430E-02	.282E-01	.478E-01	.490E-01	.438E-01	.402E-01	.390E-01
5150.0	.900E-02	.390E-01	.524E-01	.430E-01	.418E-01	.392E-01	.385E-01
5175.0	.180E-01	.462E-01	.480E-01	.375E-01	.395E-01	.389E-01	.393E-01
5200.0	.348E-01	.710E-01	.400E-01	.350E-01	.375E-01	.392E-01	.405E-01
5225.0	.718E-01	.590E-01	.330E-01	.327E-01	.369E-01	.400E-01	.418E-01

ABSORPTION COEFFICIENTS OF H2O (CONT.D)
K (PER CM AT STP)

1/CM	300 K	600 K	1000 K	1500 K	2000 K	2500 K	3000 K
5250.0	.111E 00	.368E-01	.265E-01	.330E-01	.380E-01	.420E-01	.434E-01
5275.0	.329E-01	.285E-01	.250E-01	.360E-01	.420E-01	.439E-01	.450E-01
5300.0	.281E-01	.270E-01	.270E-01	.400E-01	.475E-01	.460E-01	.462E-01
5325.0	.121E 00	.422E-01	.440E-01	.465E-01	.498E-01	.480E-01	.470E-01
5350.0	.139E 00	.105E 00	.630E-01	.538E-01	.500E-01	.485E-01	.480E-01
5375.0	.774E-01	.710E-01	.490E-01	.558E-01	.495E-01	.480E-01	.478E-01
5400.0	.858E-01	.483E-01	.408E-01	.523E-01	.485E-01	.470E-01	.460E-01
5425.0	.985E-01	.575E-01	.438E-01	.493E-01	.450E-01	.438E-01	.425E-01
5450.0	.996E-01	.682E-01	.472E-01	.445E-01	.430E-01	.418E-01	.400E-01
5475.0	.680E-01	.680E-01	.502E-01	.426E-01	.420E-01	.422E-01	.405E-01
5500.0	.325E-01	.520E-01	.502E-01	.450E-01	.428E-01	.430E-01	.418E-01
5525.0	.150E-01	.350E-01	.455E-01	.468E-01	.455E-01	.438E-01	.438E-01
5550.0	.620E-02	.238E-01	.380E-01	.448E-01	.455E-01	.435E-01	.443E-01
5575.0	.270E-02	.158E-01	.310E-01	.410E-01	.428E-01	.420E-01	.430E-01
5600.0	.113E-02	.101E-01	.250E-01	.368E-01	.400E-01	.395E-01	.405E-01
5625.0	.460E-03	.590E-02	.188E-01	.317E-01	.360E-01	.362E-01	.380E-01
5650.0	.185E-03	.310E-02	.131E-01	.259E-01	.312E-01	.330E-01	.350E-01
5675.0	.660E-04	.130E-02	.860E-02	.211E-01	.273E-01	.300E-01	.320E-01
5700.0	.270E-04	.400E-03	.500E-02	.168E-01	.230E-01	.269E-01	.288E-01
5725.0	.110E-04	.550E-04	.290E-02	.132E-01	.195E-01	.239E-01	.258E-01
5750.0	.455E-05	.145E-04	.150E-02	.100E-01	.163E-01	.211E-01	.232E-01
5775.0	.188E-05	.168E-04	.800E-03	.740E-02	.133E-01	.183E-01	.207E-01
5800.0	.670E-06	.191E-04	.600E-03	.550E-02	.109E-01	.157E-01	.184E-01
5825.0	.325E-06	.220E-04	.600E-03	.420E-02	.850E-02	.133E-01	.163E-01
5850.0	.130E-07	.250E-04	.500E-03	.340E-02	.700E-02	.110E-01	.145E-01
5875.0	.580E-08	.288E-04	.500E-03	.280E-02	.610E-02	.950E-02	.130E-01
5900.0	.230E-08	.330E-04	.500E-03	.230E-02	.540E-02	.850E-02	.120E-01
5925.0	.100E-08	.375E-04	.500E-03	.200E-02	.480E-02	.810E-02	.116E-01
5950.0	.400E-09	.430E-04	.500E-03	.180E-02	.440E-02	.780E-02	.112E-01
5975.0	.150E-09	.495E-04	.500E-03	.160E-02	.430E-02	.760E-02	.109E-01

ABSORPTION COEFFICIENTS OF H2O (CONT.D)

K (PER CM AT STP)

1/CM	300 K	600 K	1000 K	1500 K	2000 K	2500 K	3000 K
6000.0	.500E-09	.560E-04	.600E-03	.160E-02	.430E-02	.750E-02	.108E-01
6025.0	.200E-09	.645E-04	.600E-03	.150E-02	.440E-02	.740E-02	.108E-01
6050.0	.400E-09	.735E-04	.600E-03	.150E-02	.450E-02	.730E-02	.109E-01
6075.0	.600E-09	.850E-04	.700E-03	.150E-02	.470E-02	.740E-02	.111E-01
6100.0	.100E-08	.965E-04	.700E-03	.160E-02	.480E-02	.740E-02	.113E-01
6125.0	.180E-08	.113E-03	.800E-03	.160E-02	.500E-02	.760E-02	.116E-01
6150.0	.330E-08	.128E-03	.800E-03	.170E-02	.520E-02	.730E-02	.122E-01
6175.0	.600E-08	.147E-03	.900E-03	.180E-02	.550E-02	.820E-02	.126E-01
6200.0	.100E-07	.167E-03	.100E-02	.190E-02	.580E-02	.860E-02	.129E-01
6225.0	.185E-07	.191E-03	.110E-02	.210E-02	.620E-02	.910E-02	.134E-01
6250.0	.325E-07	.223E-03	.120E-02	.230E-02	.670E-02	.970E-02	.139E-01
6275.0	.560E-07	.250E-03	.130E-02	.260E-02	.710E-02	.103E-01	.144E-01
6300.0	.100E-06	.285E-03	.140E-02	.290E-02	.760E-02	.110E-01	.150E-01
6325.0	.180E-06	.330E-03	.150E-02	.330E-02	.820E-02	.118E-01	.157E-01
6350.0	.325E-06	.380E-03	.160E-02	.370E-02	.880E-02	.124E-01	.164E-01
6375.0	.570E-06	.430E-03	.180E-02	.410E-02	.940E-02	.132E-01	.172E-01
6400.0	.102E-05	.495E-03	.200E-02	.460E-02	.101E-01	.140E-01	.180E-01
6425.0	.180E-05	.565E-03	.210E-02	.520E-02	.109E-01	.148E-01	.191E-01
6450.0	.320E-05	.650E-03	.240E-02	.590E-02	.117E-01	.157E-01	.200E-01
6475.0	.580E-05	.745E-03	.260E-02	.660E-02	.124E-01	.166E-01	.211E-01
6500.0	.102E-04	.840E-03	.280E-02	.730E-02	.133E-01	.174E-01	.222E-01
6525.0	.180E-04	.980E-03	.310E-02	.810E-02	.140E-01	.185E-01	.233E-01
6550.0	.325E-04	.110E-02	.340E-02	.890E-02	.149E-01	.194E-01	.244E-01
6575.0	.570E-04	.130E-02	.370E-02	.970E-02	.159E-01	.203E-01	.255E-01
6600.0	.100E-03	.150E-02	.400E-02	.106E-01	.169E-01	.213E-01	.267E-01
6625.0	.170E-03	.170E-02	.450E-02	.116E-01	.179E-01	.223E-01	.276E-01
6650.0	.320E-03	.190E-02	.490E-02	.126E-01	.190E-01	.234E-01	.287E-01
6675.0	.600E-03	.220E-02	.550E-02	.135E-01	.200E-01	.244E-01	.296E-01
6700.0	.900E-03	.250E-02	.610E-02	.145E-01	.212E-01	.254E-01	.305E-01
6725.0	.121E-02	.280E-02	.680E-02	.155E-01	.224E-01	.263E-01	.313E-01

ABSORPTION COEFFICIENTS OF H2O (CONT.D)
K (PER CM AT STP)

1/CM	300 K	600 K	1000 K	1500 K	2000 K	2500 K	3000 K
6750.0	.152E-02	.330E-02	.770E-02	.165E-01	.235E-01	.272E-01	.320E-01
6775.0	.185E-02	.370E-02	.860E-02	.174E-01	.247E-01	.281E-01	.329E-01
6800.0	.220E-02	.430E-02	.980E-02	.184E-01	.260E-01	.290E-01	.335E-01
6825.0	.255E-02	.500E-02	.113E-01	.195E-01	.272E-01	.298E-01	.339E-01
6850.0	.290E-02	.580E-02	.130E-01	.208E-01	.285E-01	.305E-01	.343E-01
6875.0	.320E-02	.670E-02	.147E-01	.224E-01	.298E-01	.313E-01	.345E-01
6900.0	.360E-02	.880E-02	.167E-01	.240E-01	.311E-01	.319E-01	.343E-01
6925.0	.400E-02	.920E-02	.189E-01	.262E-01	.323E-01	.322E-01	.341E-01
6950.0	.460E-02	.108E-01	.212E-01	.274E-01	.334E-01	.327E-01	.39E-01
6975.0	.530E-02	.128E-01	.238E-01	.305E-01	.339E-01	.329E-01	.333E-01
7000.0	.620E-02	.152E-01	.265E-01	.325E-01	.342E-01	.330E-01	.325E-01
7025.0	.760E-02	.182E-01	.295E-01	.342E-01	.341E-01	.324E-01	.313E-01
7050.0	.980E-02	.222E-01	.340E-01	.358E-01	.339E-01	.314E-01	.299E-01
7075.0	.132E-01	.271E-01	.390E-01	.360E-01	.332E-01	.303E-01	.283E-01
7100.0	.190E-01	.335E-01	.445E-01	.355E-01	.321E-01	.291E-01	.263E-01
7125.0	.240E-01	.432E-01	.470E-01	.338E-01	.296E-01	.279E-01	.243E-01
7150.0	.288E-01	.570E-01	.420E-01	.311E-01	.271E-01	.263E-01	.223E-01
7175.0	.323E-01	.740E-01	.370E-01	.280E-01	.249E-01	.247E-01	.208E-01
7200.0	.570E-01	.890E-01	.325E-01	.252E-01	.228E-01	.228E-01	.199E-01
7225.0	.216E 00	.680E-01	.290E-01	.230E-01	.211E-01	.202E-01	.190E-01
7250.0	.126E 00	.475E-01	.285E-01	.221E-01	.200E-01	.196E-01	.187E-01
7275.0	.117E-01	.369E-01	.315E-01	.242E-01	.222E-01	.202E-01	.200E-01
7300.0	.140E-01	.370E-01	.368E-01	.273E-01	.248E-01	.222E-01	.224E-01
7325.0	.425E-01	.418E-01	.415E-01	.298E-01	.273E-01	.247E-01	.243E-01
7350.0	.640E-01	.460E-01	.440E-01	.310E-01	.290E-01	.270E-01	.260E-01
7375.0	.385E-01	.385E-01	.360E-01	.285E-01	.282E-01	.276E-01	.265E-01
7400.0	.182E-01	.179E-01	.214E-01	.245E-01	.258E-01	.268E-01	.260E-01
7425.0	.170E-01	.810E-02	.150E-01	.202E-01	.232E-01	.250E-01	.248E-01
7450.0	.161E-01	.370E-02	.100E-01	.164E-01	.204E-01	.227E-01	.228E-01
7475.0	.145E-01	.170E-02	.660E-02	.126E-01	.173E-01	.196E-01	.202E-01

50

ABSORPTION COEFFICIENTS OF H2O (CONT.D)

K (PER CM AT STP)

1/CM	300 K	600 K	1000 K	1500 K	2000 K	2500 K	3000 K
7500.0	.900E-03	.800E-03	.440E-02	.940E-02	.140E-01	.165E-01	.175E-01
7525.0	.000E 00	.000E 00	.000E 00	.000E 00	.112E-01	.126E-01	.140E-01
7550.0	.000E 00	.000E 00	.000E 00	.000E 00	.870E-02	.970E-02	.107E-01
7575.0	.000E 00	.000E 00	.000E 00	.000E 00	.640E-02	.700E-02	.760E-02
7600.0	.000E 00	.000E 00	.000E 00	.000E 00	.460E-02	.525E-02	.590E-02
7625.0	.000E 00	.000E 00	.000E 00	.000E 00	.365E-02	.437E-02	.510E-02
7650.0	.000E 00	.000E 00	.000E 00	.000E 00	.320E-02	.370E-02	.460E-02
7675.0	.000E 00	.000E 00	.000E 00	.000 E 00	.290E-02	.360E-02	.430E-02
7700.0	.000E 00	.000E 00	.000E 00	.000E 00	.270E-02	.340E-02	.410E-02
7725.0	.000E 00	.000E 00	.000E 00	.000E 00	.250E-02	.322E-02	.395E-02
7750.0	.000E 00	.000E 00	.000E 00	.000E 00	.240E-02	.315E-02	.390E-02
7775.0	.000E 00	.000E 00	.000E 00	.000E 00	.230E-02	.310E-02	.390E-02
7800.0	.000E 00	.000E 00	.000E 00	.000E 00	.225E-02	.308E-02	.390E-02
7825.0	.000E 00	.000E 00	.000E 00	.000E 00	.220E-02	.305E-02	.390E-02
7850.0	.000E 00	.000E 00	.000E 00	.000E 00	.220E-02	.305E-02	.390E-02
7875.0	.000E 00	.000E 00	.000E 00	.000E 00	.220E-02	.306E-02	.391E-02
7900.0	.000E 00	.000E 00	.000E 00	.000E 00	.220E-02	.307E-02	.393E-02
7925.0	.000E 00	.000E 00	.000E 00	.000E 00	.225E-02	.311E-02	.397E-02
7950.0	.000E 00	.000E 00	.000E 00	.000E 00	.230E-02	.315E-02	.400E-02
7975.0	.000E 00	.000E 00	.000E 00	.000E 00	.234E-02	.318E-02	.401E-02
8000.0	.000E 00	.000E 00	.000E 00	.000E 00	.240E-02	.323E-02	.406E-02
8025.0	.000E 00	.000E 00	.000E 00	.000E 00	.246E-02	.328E-02	.410E-02
8050.0	.000E 00	.000E 00	.000E 00	.000E 00	.251E-02	.335E-02	.419E-02
8075.0	.000E 00	.000E 00	.000E 00	.000E 00	.259E-02	.344E-02	.428E-02
8100.0	.000E 00	.000E 00	.000E 00	.000E 00	.265E-02	.352E-02	.438E-02
8125.0	.000E 00	.000E 00	.000E 00	.000E 00	.272E-02	.358E-02	.445E-02
8150.0	.000E 00	.000E 00	.000E 00	.000E 00	.281E-02	.369E-02	.457E-02
8175.0	.000E 00	.000E 00	.000E 00	.000E 00	.290E-02	.379E-02	.468E-02
8200.0	.000E 00	.000E 00	.000E 00	.000E 00	.300E-02	.389E-02	.479E-02
8225.0	.000E 00	.000E 00	.000E 00	.000E 00	.310E-02	.398E-02	.485E-02

ABSORPTION COEFFICIENTS OF H2O (CONT.D)
K (PER CM AT STP)

1/CM	300 K	600 K	1000 K	1500 K	2000 K	2500 K	3000 K
8250.0	.000E 00	.000E 00	.000E 00	.000E 00	.320E-02	.405E-02	.490E-02
8275.0	.000E 00	.000E 00	.000E 00	.000E 00	.330E-02	.415E-02	.499E-02
8300.0	.000E 00	.000E 00	.000E 00	.000E 00	.341E-02	.421E-02	.500E-02
8325.0	.000E 00	.000E 00	.000E 00	.000E 00	.355E-02	.426E-02	.501E-02
8350.0	.000E 00	.000E 00	.000E 00	.000E 00	.370E-02	.437E-02	.502E-02
8375.0	.000E 00	.000E 00	.000E 00	.000E 00	.380E-02	.440E-02	.501E-02
8400.0	.000E 00	.000E 00	.000E 00	.000E 00	.388E-02	.444E-02	.500E-02
8425.0	.000E 00	.000E 00	.000E 00	.000E 00	.391E-02	.445E-02	.499E-02
8450.0	.000E 00	.000E 00	.000E 00	.000E 00	.398E-02	.446E-02	.495E-02
8475.0	.000E 00	.000E 00	.000E 00	.000E 00	.400E-02	.445E-02	.490E-02
8500.0	.000E 00	.000E 00	.000E 00	.000E 00	.400E-02	.440E-02	.480E-02
8525.0	.000E 00	.000E 00	.000E 00	.000E 00	.399E-02	.437E-02	.475E-02
8550.0	.000E 00	.000E 00	.000E 00	.000E 00	.396E-02	.429E-02	.463E-02
8575.0	.000E 00	.000E 00	.000E 00	.000E 00	.391E-02	.423E-02	.455E-02
8600.0	.000E 00	.000E 00	.000E 00	.000E 00	.391E-02	.417E-02	.443E-02
8625.0	.000E 00	.000E 00	.000E 00	.000E 00	.398E-02	.416E-02	.433E-02
8650.0	.000E 00	.000E 00	.000E 00	.000E 00	.400E-02	.410E-02	.420E-02
8675.0	.000E 00	.000E 00	.000E 00	.000E 00	.399E-02	.404E-02	.408E-02
8700.0	.000E 00	.000E 00	.000E 00	.000E 00	.395E-02	.395E-02	.395E-02
8725.0	.000E 00	.000E 00	.000E 00	.000E 00	.390E-02	.385E-02	.380E-02
8750.0	.000E 00	.000E 00	.000E 00	.000E 00	.381E-02	.374E-02	.367E-02
8775.0	.000E 00	.000E 00	.000E 00	.000E 00	.372E-02	.362E-02	.351E-02
8800.0	.000E 00	.000E 00	.000E 00	.000E 00	.360E-02	.348E-02	.338E-02
8825.0	.000E 00	.000E 00	.000E 00	.000E 00	.348E-02	.336E-02	.323E-02
8850.0	.000E 00	.000E 00	.000E 00	.000E 00	.331E-02	.320E-02	.310E-02
8875.0	.000E 00	.000E 00	.000E 00	.000E 00	.313E-02	.304E-02	.299E-02
8900.0	.000E 00	.000E 00	.000E 00	.000E 00	.294E-02	.287E-02	.280E-02
8925.0	.000E 00	.000E 00	.000E 00	.000E 00	.273E-02	.270E-02	.268E-02
8950.0	.000E 00	.000E 00	.000E 00	.000E 00	.251E-02	.256E-02	.253E-02
8975.0	.000E 00	.000E 00	.000E 00	.000E 00	.230E-02	.235E-02	.240E-02

ABSORPTION COEFFICIENTS OF H2O (CONT.D)

K (PER CM AT STP)

1/CM	300 K	600 K	1000 K	1500 K	2000 K	2500 K	3000 K
9000.0	.000E 00	.000E 00	.000E 00	.000E 00	.207E-02	.223E-02	.238E-02
9025.0	.000E 00	.000E 00	.000E 00	.000E 00	.183E-02	.201E-02	.218E-02
9050.0	.000E 00	.000E 00	.000E 00	.000E 00	.162E-02	.183E-02	.207E-02
9075.0	.000E 00	.000E 00	.000E 00	.000E 00	.140E-02	.167E-02	.197E-02
9100.0	.000E 00	.000E 00	.000E 00	.000E 00	.122E-02	.155E-02	.187E-02
9125.0	.000E 00	.000E 00	.000E 00	.000E 00	.104E-02	.142E-02	.179E-02
9150.0	.000E 00	.000E 00	.000E 00	.000E 00	.880E-03	.130E-02	.171E-02
9175.0	.000E 00	.000E 00	.000E 00	.000E 00	.730E-03	.118E-02	.163E-02
9200.0	.000E 00	.000E 00	.000E 00	.000E 00	.620E-03	.109E-02	.156E-02
9225.0	.000E 00	.000E 00	.000E 00	.000E 00	.560E-03	.103E-02	.149E-02
9250.0	.000E 00	.000E 00	.000E 00	.000E 00	.530E-03	.980E-03	.143E-02
9275.0	.000E 00	.000E 00	.000E 00	.000E 00	.510E-03	.950E-03	.138E-02
9300.0	.000E 00	.000E 00	.000E 00	.000E 00	.500E-03	.920E-03	.133E-02
9325.0	.000E 00	.000E 00	.000E 00	.000E 00	.510E-03	.910E-03	.130E-02
9350.0	.000E 00	.000E 00	.000E 00	.000E 00	.530E-03	.900E-03	.127E-02
9375.0	.000E 00	.000E 00	.000E 00	.000E 00	.550E-03	.910E-03	.126E-02
9400.0	.000E 00	.000E 00	.000E 00	.000E 00	.560E-03	.910E-03	.125E-02
9425.0	.000E 00	.000E 00	.000E 00	.000E 00	.590E-03	.920E-03	.124E-02
9450.0	.000E 00	.000E 00	.000E 00	.000E 00	.610E-03	.930E-03	.124E-02
9475.0	.000E 00	.000E 00	.000E 00	.000E 00	.640E-03	.940E-03	.125E-02
9500.0	.000E 00	.000E 00	.000E 00	.000E 00	.660E-03	.960E-03	.126E-02
9525.0	.000E 00	.000E 00	.000E 00	.000E 00	.690E-03	.980E-03	.127E-02
9550.0	.000E 00	.000E 00	.000E 00	.000E 00	.720E-03	.100E-02	.128E-02
9575.0	.000E 00	.000E 00	.000E 00	.000E 00	.750E-03	.102E-02	.129E-02
9600.0	.000E 00	.000E 00	.000E 00	.000E 00	.780E-03	.104E-02	.130E-02
9625.0	.000E 00	.000E 00	.000E 00	.000E 00	.820E-03	.107E-02	.132E-02
9650.0	.000E 00	.000E 00	.000E 00	.000E 00	.860E-03	.110E-02	.133E-02
9675.0	.000E 00	.000E 00	.000E 00	.000E 00	.900E-03	.113E-02	.135E-02
9700.0	.000E 00	.000E 00	.000E 00	.000E 00	.940E-03	.116E-02	.137E-02
9725.0	.000E 00	.000E 00	.000E 00	.000E 00	.980E-03	.119E-02	.139E-02

ABSORPTION COEFFICIENTS OF H2O (CONT.D)
K (PER CM AT STP)

1/CM	300 K	600 K	1000 K	1500 K	2000 K	2500 K	3000 K
9750.0	.000E 00	.000E 00	.000E 00	.000E 00	.102E-02	.121E-02	.140E-02
9775.0	.000E 00	.000E 00	.000E 00	.000E 00	.106E-02	.124E-02	.142E-02
9800.0	.000E 00	.000E 00	.000E 00	.000E 00	.110E-02	.127E-02	.144E-02
9825.0	.000E 00	.000E 00	.000E 00	.000E 00	.113E-02	.130E-02	.147E-02
9850.0	.000E 00	.000E 00	.000E 00	.000E 00	.118E-02	.133E-02	.148E-04
9875.0	.000E 00	.000E 00	.000E 00	.000E 00	.122E-02	.136E-02	.150E-02
9900.0	.000E 00	.000E 00	.000E 00	.000E 00	.126E-02	.139E-02	.152E-02
9925.0	.000E 00	.000E 00	.000E 00	.000E 00	.130E-02	.142E-02	.154E-02
9950.0	.000E 00	.000E 00	.000E 00	.000E 00	.133E-02	.14?E-02	.157E-02
9975.0	.000E 00	.000E 00	.000E 00	.000E 00	.137E-02	.148E-02	.159E-02
10000.0	.000E 00	.000E 00	.000E 00	.000E 00	.141E-02	.151E-02	.161E-02
10025.0	.000E 00	.000E 00	.000E 00	.000E 00	.144E-02	.153E-02	.161E-02
10050.0	.000E 00	.000E 00	.000E 00	.000E 00	.147E-02	.154E-02	.161E-02
10075.0	.000E 00	.000E 00	.000E 00	.000E 00	.150E-02	.155E-02	.160E-02
10100.0	.000E 00	.000E 00	.000E 00	.000E 00	.152E-02	.156E-02	.160E-02
10125.0	.000E 00	.000E 00	.000E 00	.000E 00	.156E-02	.157E-02	.158E-02
10150.0	.000E 00	.000E 00	.000E 00	.000E 00	.158E-02	.157E-02	.157E-02
10175.0	.000E 00	.000E 00	.000E 00	.000E 00	.157E-02	.156E-02	.154E-02
10200.0	.000E 00	.000E 00	.000E 00	.000E 00	.155E-02	.15?E-02	.152E-02
10225.0	.000E 00	.000E 00	.000E 00	.000E 00	.153E-02	.151E-02	.149E-02
10250.0	.000E 00	.000E 00	.000E 00	.000E 00	.150E-02	.148E-02	.147E-02
10275.0	.000E 00	.000E 00	.000E 00	.000E 00	.147E-02	.145E-02	.143E-02
10300.0	.000E 00	.000E 00	.000E 00	.000E 00	.143E-02	.142E-02	.140E-02
10325.0	.000E 00	.000E 00	.000E 00	.000E 00	.138E-02	.137E-02	.137E-02
10350.0	.000E 00	.000E 00	.000E 00	.000E 00	.133E-02	.133E-02	.133E-02
10375.0	.000E 00	.000E 00	.000E 00	.000E 00	.125E-02	.128E-02	.131E-02
10400.0	.000E 00	.000E 00	.000E 00	.000E 00	.120E-02	.126E-02	.132E-02
10425.0	.000E 00	.000E 00	.000E 00	.000E 00	.121E-02	.127E-02	.133E-02
10450.0	.000E 00	.000E 00	.000E 00	.000E 00	.125E-02	.131E-02	.137E-02
10475.0	.000E 00	.000E 00	.000E 00	.000E 00	.128E-02	.133E-02	.139E-02

ABSORPTION COEFFICIENTS OF H2O (CONT.D)

K (PER CM AT STP)

1/CM	300 K	600 K	1000 K	1500 K	2000 K	2500 K	3000 K
10500.0	.000E 00	.000E 00	.000E 00	.000E 00	.133E-02	.137E-02	.141E-02
10525.0	.000E 00	.000E 00	.000E 00	.000E 00	.137E-02	.140E-02	.143E-02
10550.0	.000E 00	.000E 00	.000E 00	.000E 00	.140E-02	.142E-02	.143E-02
10575.0	.000E 00	.000E 00	.000E 00	.000E 00	.141E-02	.141E-02	.142E-02
10600.0	.000E 00	.000E 00	.000E 00	.000E 00	.137E-02	.137E-02	.137E-02
10625.0	.000E 00	.000E 00	.000E 00	.000E 00	.128E-02	.125E-02	.123E-02
10650.0	.000E 00	.000E 00	.000E 00	.000E 00	.110E-02	.109E-02	.108E-02
10675.0	.000E 00	.000E 00	.000E 00	.000E 00	.950E-03	.960E-03	.960E-03
10700.0	.000E 00	.000E 00	.000E 00	.000E 00	.820E-03	.830E-03	.840E-03
10725.0	.000E 00	.000E 00	.000E 00	.000E 00	.680E-03	.700E-03	.720E-03
10750.0	.000E 00	.000E 00	.000E 00	.000E 00	.540E-03	.580E-03	.620E-03
10775.0	.000E 00	.000E 00	.000E 00	.000E 00	.410E-03	.470E-03	.520E-03
10800.0	.000E 00	.000E 00	.000E 00	.000E 00	.320E-03	.380E-03	.430E-03
10825.0	.000E 00	.000E 00	.000E 00	.000E 00	.290E-03	.340E-03	.390E-03
10850.0	.000E 00	.000E 00	.000E 00	.000E 00	.280E-03	.320E-03	.360E-03
10875.0	.000E 00	.000E 00	.000E 00	.000E 00	.270E-03	.310E-03	.340E-03
10900.0	.000E 00	.000E 00	.000E 00	.000E 00	.270E-03	.300E-03	.320E-03
10925.0	.000E 00	.000E 00	.000E 00	.000E 00	.260E-03	.290E-03	.310E-03
10950.0	.000E 00	.000E 00	.000E 00	.000E 00	.260E-03	.280E-03	.290E-03
10975.0	.000E 00	.000E 00	.000E 00	.000E 00	.250E-03	.270E-03	.280E-03
11000.0	.000E 00	.000E 00	.000E 00	.000E 00	.250E-03	.250E-03	.260E-03